STRUCTURE OF SYLLABUS FOR THE

PROGRAM: M.Sc. STATISTICS

Syllabus Developed by		
Name of BoS Convener	**Designation**	**College/University**
DR. NIDHI NAGAR SAXENA	Convener	Dayanand Anglo-Vedic (PG) College, Civil Lines, Kanpur

Semester/Year	**Course Code**		**Paper Title**	**Credits**	**Remarks**		
			SEMESTER I				
I Semester	B060701T	Core Course	Linear Methods	4	25	75	100
	B060702T	Core Course	Measure Theory & Probability	4	25	75	100
	B060703T	Core Course	Data Analysis using R	4	25	75	100
	B060704T	Elective Course	Real Analysis	4	25	75	100
	B060705T		Introductory Mathematical Statistics				
	B060706P	PRACTICAL	Practical/Lab	4	25	75	100
			SEMESTER II				
II Semester	B060801T	Core	Multivariate Analysis	4	25	75	100
	B060802T	Core	Design of Experiments	4	25	75	100
	B060803T	Core	Sampling Theory	4	25	75	100
	B060804T	Elective	Reliability Theory & Life Distributions	4	25	75	100
	B060805T		Demography				
	B060806P	PRACTICAL	Practical/Lab	4	25	75	100
	B060807R	RESEARCH	Research Project/Dissertation	8	25	75	100
		MINOR ELECTIVE	FROM OTHER FACULTY (in Ist Year)	4/5/6	25	75	100
			SEMESTER III				
III Semester	B060901T	Core	Econometrics	4	25	75	100
	B060902T	Core	Optimization Techniques	4	25	75	100
	B060903T	Core	Statistical Inference	4	25	75	100
	B060904T	Elective	Industrial Statistics	4	25	75	100
	B060905T		Psychological Statistics	4	25	75	100
	B060906P	PRACTICAL	Practical/Lab	4	25	75	100
			SEMESTER IV				
IV Semester	B061001T	Core	Applied Regression Analysis	4	25	75	100
	B061002T	Core	Stochastic Processes	4	25	75	100
	B061003T	Elective	Biostatistics	4	25	75	100
	B061004T		Actuarial Statistics		25	75	100
	B061005T	Elective	Statistical Analysis using SPSS	4	25	75	100
	B061006T		C programming		25	75	100

	B061007P	PRACTICAL	Practical/Lab	4	25	75	100
	B061008R	RESEARCH	Research Project/ Dissertation	8	25	75	100

M.Sc. (Previous) Statistics

SEMESTER I

B060701T: LINEAR METHODS **Credit: 4**

Course Objective: To provide necessary foundations on Mathematics and Statistics which enable the students to calculate and interpret Statistical measures appropriately.

Learning Outcomes: Students are expected to:

- use the definitions of vector space and related things and determine the orthonormal basis
- understand the linear transformation and its matrix representation
- have awareness of Matrix theory concepts that can be used further in Multivariate Analysis and Designs of Experiments
- to understand the scientific value of the traditional knowledge of India

UNIT I	Contribution of Indian Knowledge system to the development of Statistical thought; Finite dimensional vector spaces, existence of basis, orthogonal matrices, Gram-Schmidt orthogonalisation method, Algebra of matrices, rank and inverse of matrix
UNIT II	Linear transformation and their matrix representation, Solution of linear equations, generalized inverse of matrix & its elementary properties
UNIT III	Characteristic roots & vector of a matrix. Cayley-Hamilton theorem, idempotent matrices, real quadratic forms, definiteness of a real quadratic form, reduction and classification of quadratic forms
UNIT IV	Linear estimations: linear models with assumption of error components, estimable functions & error spaces, BLUE, Testing of general linear hypothesis under normality of errors
REFERENCES	Bapat, R. B. (2012) Linear Algebra and Linear Models, Springer-Verlag, London Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., & Rao, C. R. (1973). *Linear statistical inference and its applications* (Vol. 2, pp. 263-270). New York: Wiley. Biswas, S. (2012). *Textbook of Matrix Algebra*. PHI Learning Pvt. Ltd. Searie S.R. Linear Models (Wiley) Searie S.R. (1982) Matrix Algebra useful for Statistics (Wiley)

	David A Harville. Matrix Algebra from a Statistician's Perspective; Springer Graybill FA (1983). Matrices with applications in Statistics. John Wiley & Sons

B060702T: MEASURE THEORY & PROBABILITY **Credit: 4**

Course Objective: This course covers the fundamentals of probability theory using measure theoretical approach. It focuses on the utility of abstract concepts such as W.L.L.N., S.L.L.N. and teaches their applicability along with an understanding and construction of proofs.

Learning Outcomes: By the end of the course, the students should be able to**:**

- understand the concept of sigma field, borel field and measures
- determine the concept of measurable function, characteristic functions and related results
- understand the different modes of convergence and applicability of W.L.L.N., S.L.L.N

UNIT I	Sets,Class of sets, Fields, sigma fields, minimal sigma field, borel sigma field, sequence of sets, monotone classes of sets
UNIT II	Set function, continuity of set function, measure function, properties of measure function, probability measure and probability space, lebesgue measure, lebesgue-stieltjes measure and its properties, Caratheodory Extension Theorem of measure function(statement only)
UNIT III	Measurable function, random variable as a measurable function, sequences of Measurable function and random variables, monotone convergence theorem, Convergence of sequence of random variables- in distribution, in probability, in r^{th} mean and almost everywhere, their criteria and inter-relations. Helly-Bray Theorem (statement only)
UNIT IV	Borel cantelli lemma, Borel 0-1 law , Khintchine's Weak & Strong law of large numbers and Kolmogoroff's theorems Central limit theorems: Linderberg-Levy theorem; Laplace-Liapunoff theorem; Linderberg-Feller theorem (statement only) Characteristics functions, uniqueness theorem, inversion theorem
REFERENCES	Feller W. (2008) An Introduction to Probability Theory and its Applications, Vol II, Second edition, Wiley India (P) Ltd. Billingsley P (2008): Probability and Measure, Third edition, Wiley India Pvt. Ltd. Halmos, P. R. (2013). *Measure theory* (Vol. 18). Springer.

	Kubrusly, C. S. (2015). *Essentials of measure theory*. Springer International Publishing. Doob, J. L. (2012). *Measure theory* (Vol. 143). Springer Science & Business Media. Bhat, B. R. (2007). *Modern probability theory*. New Age International. Ash, R. B., Robert, B., Doleans-Dade, C. A., & Catherine, A. (2000). *Probability and measure theory*. Academic press. Loeve, M. (2017). *Probability theory*. Courier Dover Publications. Chow, Y. S., & Teicher, H. (2003). *Probability theory: independence, interchangeability, martingales*. Springer Science & Business Media. Rohtagi V.K. and Saleh A.K. Md E(2008) An introduction to Probability Theory and Mathematical Statistics. John Wiley & Sons, New York

B060703T: DATA SCIENCE USING R **Credit: 4**

Course Objective: To provide the necessary foundations on handling of computer system, statistical software and impart basic knowledge of programming language 'R'.

Learning Outcomes: Students are expected to

- understand how to use the command and syntax of R for statistical calculations
- understand the applicability of the statistical tools as per the data and other analytical requirements
- apply statistical techniques on real life complex statistical data

UNIT I	Introduction to the statistical software ; installation procedure, packages library, R-studio, Overview of R, Basic File operations: Data objects in R, Reading & Writing Data ,Creating vectors, Creating matrices
UNIT II	Manipulating data, Accessing elements of a vector or matrix, lists, Manipulating vectors, matrices, lists, importing of files, data frame, Boolean operators.
UNIT III	Control Structures, Function, Looping: For loop, repeat loop, while loop, if command, if else command.; Scoping Rules, Computations of descriptive statistics measures-univariate data, frequency table, Handling bivariate data ,
UNIT IV	R-Graphics- Histogram, Box-plot, Stem and leaf plot, Plotting of probability distributions and sampling distributions, Scatter plot, Simulation.

REFERENCES	Wickham, H. (2008). A First Course in Statistical Programming with R. *Journal of Statistical Software, 28*, 1-3. Purohit S.G., Gore,S.D. and Deshmukh,S.R.(2008) Statistics Using R, Alpha Science W. John Braun and D. J. Murdoch (2007); A Frist Course in statistical programming with R parametric inference. Cambridge University Press. Alain F. Zuur, Elena N. Ieno, and Erik Meesters, "A Beginner's Guide to R", Springer, 2009, ISBN:978-0-387-93836-3. W Michael J. Crawley, "Statistics: An Introduction using R", Wiley, 2005, ISBN 0-470-02297-3. Phil Spector, "Data Manipulation with R", Springer, New York, 2008, ISBN 978-0-387-74730-9. Maria L. Rizzo, "Statistical computing with R", Chapman & Hall/CRC, Boca Raton, FL, 2008, ISBN 1-584-88545-9. W. John Braun and Duncan J. Murdoch, "A first course in Statistical programming with R", Cambridge University Press, Cambridge, 2007, ISBN 978-0521872652. Hothorn,T and Everitt, B.S.(2014). A Handbook of Statistical Analyses Using R. Chapman & Hall/CRC Press, Boca Raton, Florida, USA, 3rd edition. Knell, R.J. (2013), Introductory R: A Beginner's Guide to Data Visualisation and Analysis using R. Kundu, D. and Basu, A. (2004) Statistical computing – existing methods and recent developments, Narosa publishing house, New Delhi Monahan, J.F. (2001) Numerical methods of statistics, Cambridge University Press. Tattar Prabhanjan and Ramaiah, S. and Manjunath, B.G. A Course in Statistics with R, 1st Edition, Wiley Lander J. P. (2014). R for Everyone: Advanced Analytics and Graphics, Pearson

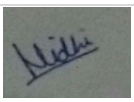
B060704T: REAL ANALYSIS **Credit: 4**

Course Objective: This course covers the fundamentals of real analysis and focuses on the utility of the abstract concepts.

Learning Outcomes: By the end of the course, students should be able to:

- Understand the concept of series of real numbers
- Determine the limit and continuity of functions defined on subsets of real line
- Recognize difference between point wise and uniform convergence of a sequence of functions

UNIT I	Real valued functions, continuity of functions of one variable, uniform continuity. Differentiability, Mean value theorem, Taylor's theorem



UNIT II	Maximum-minima of functions of many variables (method of undetermined multipliers only), Fundamental theorem and mean value theorem of integral calculus
UNIT III	Test of convergence of infinite integrals, uniform convergence of improper integrals, differentiations under the sign of integral
UNIT IV	Multiple integrals and their evaluation by repeated integration, change of variables in multiple integration, Drichlet's Multiple integral
REFERENCES	Apostol, T. M. (1965). A Course in Mathematical Analysis, Vol. II. Dudley, R. M. (2018). *Real analysis and probability*. CRC Press. Rudin, W. (1976). *Principles of mathematical analysis* (Vol. 3). New York: McGraw-hill. Bartle R G and Sherbert D R (2011), Introduction to Real Analysis, Wiley India Edition Kumar A and Kumaresan S (2014). A Basic Course in Real Analysis, CRC Press

B060705T: INTRODUCTORY MATHEMATICAL STATISTICS **Credit: 4**
(Only for students having Graduation without Statistics)

Course Objective: This course covers the fundamentals of mathematical statistics introduced at under-graduate level

Learning Outcomes: By the end of the course, students who have graduation without Statistics should be able to:

- Understand the concept of randomness, probability and know about the elementary distributions
- Determine expectation and other various functions based on pdf/pmf (distribution function, m.g.f., cumulants etc.)
- Understand basics of sampling, design of experiments

UNIT I	Probability: Axiomatic definition of Probability, Independent events, Baye's Theorem, Discrete and Continuous random variables (Binomial, Poisson's, Normal distribution, exponential distribution, uniform and rectangular distribution) Distribution Functions: Probability Mass function and Probability density function, Moments, Moment Generating function: Characteristic function, cumulant generating function, moments in terms of cumulants (for the above distributions)

UNIT II	Biavariate data, Moments of Bivariate Distribution, Continuous bivariate probability distribution, bivariate normal distribution, marginal and conditional bivariate distribution, Mathematical Expectation of random variables, joint distribution function of two random variables, conditional and marginal pdf and pmf, conditional expectation, chebyshev's and Markov's inequalities, Correlation Coefficient, Regression, Method of Least Squares and Curve Fitting, Partial and Multiple Correlation for three variables
UNIT III	Sampling theory: Definition of Statistic, population, frame, concept of sampling distribution Methods of sampling- simple random sampling with and without replacement, stratified random sampling, neyman allocation, proportional allocation, optimum allocation
UNIT IV	Estimation and testing: Properties of estimators-unbiasedness, consistency, sufficiency; two types of errors in testing of hypothesis, Neyman Pearson Lemma, Problems based on NP Lemma Design of Experiments and Analysis of Variance: One-Way and Two-way classification, Principles of design, CRD, RBD and Latin Square Design Simple testing problems based on Chi-square distribution, t, F and Z distributions
REFERENCES	Freund, J. E. (2001): Mathematical Statistics, Prentice Hall of India Goon A.M. Gupta, M.K. & Dasgupta, B. (2002). Fundamentals of Statistics, Vol I., Kolkata, The World Press Hogg, R. V., Mc Kean, J. W. & Craig, A.T. (2009). Introduction to Mathematical Statistics (6^{th} Edition), Pearson Sukhatme, P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press ukhopadhyay, P. (2008). Theory and methods of survey sampling. PHI Learning Pvt. Ltd.. Cochran, W.G. (2002). Sampling Techniques. Wiley Montgomery, D. C. (2017). *Design and analysis of experiments*. John wiley & sons.

B060706P: PRACTICAL/LAB **Credit: 4**

Based on Theory papers of First Semester

SEMESTER II

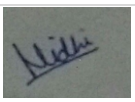
B060801T: MULTIVARIATE ANALYSIS **Credit: 4**

Course Objective: The objective of this course is to impart necessary knowledge about theoretical aspects of multivariate distribution theory emphasizing the inferential procedures related to random sampling from multivariate populations.

Learning Outcomes: After successful completion of the course students shall be able to:

- Understand the various types of multivariate distributions
- Have deeper understanding of inferential procedures related to such populations
- Acquire knowledge of multivariate regression and other analytical procedures
- Apply commonly used multivariate data analysis techniques and interpret results

UNIT I	Multivariate normal distribution, marginal and conditional distribution, characteristic function and moments, estimation of parameters (MLE), distribution of sample mean vector
UNIT II	Wishart matrix-distribution and properties Distribution of simple correlation coefficient, application in testing and interval estimation
UNIT III	Mahalanobis-D^2 and distribution of Hotelling's T^2 statistics and its applications in tests on mean vector for one or more multivariate normal populations and also on the equality of the components of a mean vector in multivariate population
UNIT IV	Classification and discrimination procedures-Factor analysis, discriminant analysis, canonical correlations, principal component analysis
REFERENCES	Anderson, T.W. (1983): An Introduction to multivariate statistical analysis. 2nd Ed.Wiley. Martin Bilodeau, David Brenner (1999).Theory of multivariate statistics, Springer. Bhuyan K.C. (2005). Multivariate Analysis and its Applications, Johnson, R. and Wychern (1992): Applied multivariate Statistical analysis, Prentice –Hall, 3rd Ed. Giri N C (1977) Multivariate Statistical Inference (Academic Press) Morrison, D.F. (1976): Multivariate statistical methods. 2nd.Ed. McGraw Hill.



	Rencher, A.C.(1998). Multivariate Statistical Inference with Applications, Springer. Seber, G.A. F. (2001): Multivariate observations. Wiley. Alvin C Rencher. Methods of multivariate analysis. 2nd ed. USA: Wiley interscience; 2002. TenkoRaykov& George A Marcoulides. An introduction to applied multivariate analysis. Taylor & Francis Group USA

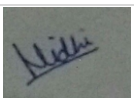
B060802T: DESIGN OF EXPERIMENTS **Credit: 4**

Course Objective: To provide background on the fundamental theories and practices of statistical design of experiments used in various disciplines including the agriculture, medicine and biological fields

Learning Outcomes: By the end of the course the students shall be able to

- Comprehend the theory as well as applicability of design of experiments in different contexts
- Understand the concept of confounding, balance , completeness in designs
- Apply the various complete and incomplete designs

UNIT I	ANOVA in general two-way classification, Missing plot design, split plot design
UNIT II	General block design & its information matrix, Criteria of connectedness and orthonormality. Balanced and partially balanced design, analysis of bock designs, extension to row-column designs
UNIT III	BIBD, recovery of inter &intra block information in BIBD, Lattice design
UNIT IV	General factorial experiments, factorial effects, best estimates & testing the significance of factorial effects, Complete & partial confounding, fractional replication for symmetric factorials
REFERENCES	Montgomery, D. C. (2017). *Design and analysis of experiments*. John wiley & sons. Angela Dean & Daniel Voss (2006). Design and Analysis of Experiments, Springer Verlag Campbell M.J, Machin D. & Walters S.J (2007). Medical Statistics – A Text Book for the Health Sciences, Wiley. Cochran & Cox (2000). Experimental Designs, Wiley Asia



	Das M.N. & Giri N.C. (2006). Design and Analysis of Experiments, New Age Publications Hinkelmann, K., & Kempthorne, O. (2007). *Design and analysis of experiments, volume 1: Introduction to experimental design* (Vol. 1). John Wiley & Sons. Joshi, D. D., & Joshi, D. D. (1987). *Linear estimation and design of experiments*. New Age International. Casella, G., Fienberg, S., & Olkin, I. (2008). *Statistical design* (pp. 32611-38545). New York: Springer. John, P. W. (1998). *Statistical design and analysis of experiments*. Society for Industrial and Applied Mathematics. Giri, N. C. (1979). *Design and analysis of experiments*. New Age International. Friedman IM Furberg CD Demets DL. Fundamentals of clinical trials. 4th edition. Springer. 2010. Meinert CL. Clinical trials: Design conduct and analysis. 2nd edition. New York: Oxford University Press. 2012. Pocock S. Clinical trials – A practical approach. John Wiley & Sons. 2010. Campbell DT Shadish WR Cook TD. Experimental and quasi experimental designs for generalized causal inference. New York: Houghton Mifflin. 2002

B060803T: SAMPLING THEORY **Credit: 4**

Course Objective: The objective of the course is to define the concepts of population under study and describe the various sampling methods and their applicability in different contexts.

Learning Outcomes: After the study of the course, the students shall be able to:

- Understand the population, sample, sampling frame
- Adopt the appropriate sampling plan in different situation
- Develop meaningful inferences

UNIT I	An outline of fixed-population and super-population approaches, complete enumeration versus sampling, basic concepts in sampling, distinctive features of finite population sampling, probability sampling designs, Ratio and regression methods of estimation involving auxiliary variables
UNIT II	Equal size cluster sampling: estimators of population mean and total and their standard errors, comparison of cluster sampling with SRS in terms of intra-class correlation coefficient. Two-stage sampling with equal number of second stage units, estimation of population mean and total.

UNIT III	Concept of multistage sampling and its application, Sampling with probability proportional to size (with and without replacement method), cumulative sum method, Lahiri's method. Ordered estimator: Desraj's estimators; Unordered estimator: Murthy's estimator for sample size 2, Horvitz-Thomson's estimator
UNIT IV	Sampling and Non-sampling error, types of non-sampling errors and their sources. Incomplete surveys, Hansen and Hurwitz Technique, Randomised response technique: Warner's Method, Observational errors
REFERENCES	Nassiuma, D. K. (2001). Survey sampling: Theory and methods. Wu, C., & Thompson, M. E. (2020). Sampling theory and practice. Cham: Springer International Publishing. Chaudhuri, A., & Stenger, H. (2005). Survey sampling: theory and methods. CRC Press. Mukhopadhyay, P. (2008). Theory and methods of survey sampling. PHI Learning Pvt. Ltd.. Cochran, W.G. (2002). Sampling Techniques. Wiley Des Raj and Chandhok (1998). Sampling Theory, Narosa. Murthy, M.N. (1967). Sampling Theory and Methods. Statistical Publishing Company, Calcutta. Sukhatme, P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press ukhopadhyay, P. (2008). Theory and methods of survey sampling. PHI Learning Pvt. Ltd.. Cochran, W.G. (2002). Sampling Techniques. Wiley Sampath S.(2005). Sampling Theory and Methods. Narosa Publishing House

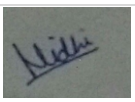
B060804T: RELIABILITY THEORY & LIFE DISTRIBUTIONS **Credit: 4**

Course Objective: The main objective o this course is to describe the theoretical aspects of reliability and related concepts

Learning Outcomes: By the end of the course, the students should be able to:

- Define reliability and estimate it
- use different lifetime distributions under complete sample for estimation of reiability

UNIT I	Basic concepts of reliability and measures, components and systems, failure rate and reliability functions, reliability of series and parallel systems and other simple configurations



UNIT II	Coherent systems, Reliability of coherent systems, hazard rate concepts, Failure models: exponential, Weibull, normal, lognormal.
UNIT III	Common life distributions and their properties-exponential, weibull, Gamma, log normal, renewal density and renewal function
UNIT IV	Estimation of parameters of these distributions & estimation of reliability. Idea of two type censored sampling, Problems in life testing, censored and truncated experiments for exponential models.
REFERENCES	Crowder, M. J., Kimber, A. C., Smith, R. L., & Sweeting, T. J. (2017). *Statistical analysis of reliability data*. Routledge. Barlow R E and Proschen F (1985) Statistical Theory of Reliability and Life Testing. Holt, Rinchart and Winston Lawless J F (1982) Statistical Models and Methods of Life Time Data. John Wiley Bain L J and Engelhardt(1991) Statistical Analysis of Relibaility and life tesing models Balagurusamy E (2017) Reliability Engineering. Wiley. Nelson W B (2003) applied Life Data Analysis. Wiley Sinha S K (1986). Reliability and Life Testing. Wiley

B060805T: DEMOGRAPHY **Credit: 4**

Course Objectives: To introduce students the basic concepts of demography and impart skills in the basic measures of population growth fertility mortality migration and urbanization.

Learning Outcomes: It is expected that students will be able to

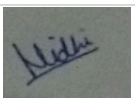
- understand the basic concepts of demography
- Get skilled in the basic measures of population growth fertility mortality migration and urbanization,
- understand socio-economic factors influencing fertility mortality and migration

UNIT I	Demographic data from census, registration, NSS other surveys, their limitations and uses, definition, construction and uses of vital rates and ratios, mortality rate, standardized death rate, complete and abridged life tables, construction of life tables from vital statistics and census returns, uses of life tables, logistic and other population growth curves, fitting a logistic curve, population projection, stable population, quasi-stable population, techniques in estimation of demographic parameters

UNIT II	Vital Events and Registration, Population and Health surveys – Civil Registration System (CRS), Sample Registration System (SRS), National Sample Survey (NSS), National Family Health Survey (NFHS), District Level Health Surveys (DLHS), Reproductive and Child Health Survey (RCHS) – Nature and limitation of data
UNIT III	Nuptiality in Indian and International Context, Measures of Nuptiality, Definition of Natural Fertility, Fertility, Fecundity, Fecundability, Measures of Fertility, Measures of Reproduction, Concepts of Cohort and Period fertility, Sources of fertility data
UNIT IV	Pattern of World Urbanization, Pattern of Urbanization in India, Components of Urban Growth; Mega cities and Urbanization, Definition of Migration, Types of Migration, Demographic diversity
REFERENCES	Pressat R. & Atherton A. (1972). Demographic Analysis. Preston S.H.,Heuveline P. & Guillot M. Demography-Measuring and Modelling Population Processes. Deshpande, J.V. and Purohit,S.G.(2005) Life Time Data: Statistical Models And Methods,World Scientific Samuel H. Preston Patrick Henveline and Michel Guillot (2001) Demography: Measuring and Modeling, Blackwell Publisher. Nathan Keyfitz (1968) Introduction to the Mathematics of Population Addison –Wesley Publishing Company Reading Massachusettes Jacob S. Siegel and David a. Swanson (2004): The Methods and Materials of Demography Second Edition Chapters 1 2 3 7 910 Elsevier Science USA. Asha A. Bhende and Tara Kanitkar(2003) Principles of Population Studies Sixteenth Revised Edition Himalaya Publishing House Mumbai. John R. Weeks (2005) Population: An Introduction to Concepts and IssuesNineth Edition Wadsworth Publishing Company Belmont California Pathak K.B.andF.Ram(1998): Techniques of Demographic Analysis2 Nd Ed Himalaya Publishing house Bombay United Nations (1974): Methods of Measuring Internal Migration Manual VI UN New York. United Nations (2004): World Urbanization Prospects The 2003 Revision New York.

B060806P: PRACTICAL/LAB **Credit: 4**

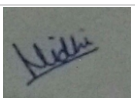
Based on Theory papers of Second Semester



B060807R: RESEARCH PROJECT REPORT II SEMESTER **Credit: 4+4**

Research work will be compiled in the form of written report. Students will be evaluated at the end of the first year (II Semester) in quality and understanding of the process regarding data dissemination, interpretation and defense along with presentation techniques in the report.

Note: More thrust on research on topics related to Indian Knowledge System.



M.Sc. (Final) Statistics

SEMESTER III

B060901T: ECONOMETRICS **Credit: 4**

Course Objective: The course is designed to develop an intuitive and conceptual understanding of regression and simultaneous equation models for describing and estimating the economic phenomenon. It focuses on formulation, estimation and testing econometric models when assumptions of classical model are violated.

Learning Outcomes: After successful completion of the course, the student shall be able to:

- Understand various econometric models, estimation methods and related econometric theories
- Have deeper understanding of assumptions, estimation and testing of hypothesis in regression models
- Be able to describe the effects of violation of assumptions of classical model and apply appropriate alternative models
- Develop regression models and understand estimation procedures for simultaneous equation models

UNIT I	Nature of Econometrics, GLM, OLSE and prediction, Generalized least squares & prediction. Test of significance and confidence intervals, use of orthogonal polynomials
UNIT II	Heteroscedastic disturbances and its solutions, Autocorrelation, its consequences. Durbin-Watson test, Multicollinearity problem, its implication and tools for handling the problem, Ridge regression
UNIT III	Autoregressive linear regression, distributed lag model. Introduction to non-linear models. Intrinsically non-linear models. Linearization (Taylor's series) method of estimation of structural parameters
UNIT IV	Simultaneous linear equation model Examples. Identification problems, restriction on structural parameters. Rank order conditions. Estimation in simultaneous equation model. Indirect least squares, 2SLS, General outline of LIML and FIML estimators
REFERENCES	Koutsoyiannis, A. (1975). *Modern microeconomics*. Springer. Johnston, J., & DiNardo, J. (1963). *Econometric methods* (Vol. 17). New York. Amemiya, T. (1973). Nonlinear Methods in Econometrics. Gujarati, D. N. (2011). *Econometrics by example* (Vol. 1). New York: Palgrave Macmillan. Gujarati, D. N. (2021). *Essentials of econometrics*. SAGE Publications.

	Dadkhah, K. M. (1984). Introduction to the Theory and Practice of Econometrics.

B060902T: OPTIMIZATION TECHNIQUES **Credit: 4**

Objectives: To teach the students important applications of operations research and to provide concepts, identification of problem and solution related to different types of data.

Learning Outcomes: Students will be able to utilize fundamentals and use of the applications of operations research and to provide concepts, identification of problem student will be able to decide about application of operation research and its role for real life studies. Besides they shall be able to:

- Understand the decision making problems logically
- Be capable of mathematical formulation of real life problems
- Be able to select appropriate optimization and computational technique for the context

UNIT I	Assignment problems, Sequencing problems Dynamic Programming Methodology: examples and applications Integer Programming- Formulation, unimodularity, Cutting plane method, Branch and Bound method
UNIT II	Network scheduling by PERT/CPM Non-linear programming-solution, convex and concave functions, Kuhn-Tucker conditions for constrained optimization, Quadratic programming, Separable programming
UNIT III	Replacement Problems, Inventory control-Objectives, functions and classifications of inventory, factors affecting inventory, Inventory modeling-deterministic demand models and probabilistic demand models, deterministic single/multi item inventory models, single period/multi period probabilistic models, Inventory control systems (fixed order quantity system and periodic review system)
UNIT IV	Game Theory-Introduction, Saddle point, Principle of dominance; mixed strategies; 2Xn games Simulation-Introduction, examples of hand computed and computer simulation, reasons for using simulation, limitations, steps in simulation process, applications
REFERENCES	Taha H.A. (1982) Operational Research: An introduction; Macmillan. Philips D.T., Ravindran A. and Solberg J. Operation Research, Principles and Practice KantiSwarup, P.K. and Singh,M.M.. (1985) Operation Research; Sultan Chand & Sons.

	Hillier F.S. and Lieberman G.J. (1962) Introduction to Operation Research; HoldenDay. Saaty T.L. (1961) Elements of Queuing Theory with Applications; McGraw Hill. Churchman C.W, Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research R. Panneerselvam(2002): Operations Research: Prentice Hall Mustafi, C.K. (1988): Operations Research, Methods and Practice, Wiley Eastern Limited

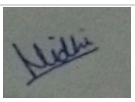
B060903T: STATISTICAL INFERENCE **Credit: 4**

Course Objective: The objective of this course is to furnish details of theory of estimation and testing of hypothesis including the foundation knowledge of Bayesian estimation.

Learning Outcomes: After the successful completion of this course, the student shall be able to:

- Acquire deeper theoretical knowledge of statistical estimation , different types of estimators
- Learn about the properties of estimators
- Have deeper understanding of testing of hypothesis

UNIT I	Estimation by methods of moments, maximum likelihood, least squares, minimum chi-square and modified minimum chi-square, properties of maximum likelihood and other estimators, asymptotic efficiency,
UNIT II	Consistency, unbiasedness, efficiency, sufficiency, completeness, ancillary statistics, factorization theorem, exponential family of distribution and its properties, uniformly minimum variance unbiased (UMVU) estimation
UNIT III	Prior and posterior distributions, loss function, risk function, and minimax estimator. Bayes estimators.
UNIT IV	MP tests, Neyman-Pearson lemma, UMP tests, monotone likelihood ratio, similar and unbiased tests, UMPU tests for single parameter likelihood ratio test and its asymptotic distribution. Confidence bounds and its relation with tests.
REFERENCES	Rohatgi V.K. & Saleh, An Introduction to Probability and Mathematical Statistics Casella G &Berger R. L., Statistical Inference Kale B. K., A First Course on Parametric Inference Dudewicz e. J. Mishra S.N., Modern Mathematical Statistics Mood A.M., Graybill F.A. and Boes D.C. , introduction to Theory of Statistics



B060904T: INDUSTRIAL STATISTICS **Credit: 4**

Course Objective: The objective of the course is to impart necessary knowledge about theoretical as well as practical aspects of statistical quality control

Learning Outcomes: After successful completion of the course the student will be able to:

- Understand the meaning of Quality and its measurement
- Acquire knowledge of various control charts and their applications
- Have a deeper understanding of acceptance sampling plans

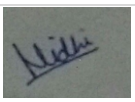
UNIT I	Quality of product , need for quality control, Process and Product control, General theory of control charts, different types of control charts for variables and attributes: X, R, s, p, np and c charts,
UNIT II	OC and ARL of control charts, Cumulative Sum Charts
UNIT III	Acceptance sampling plans, Single, double, multiple and sequential sampling plans for attributes, OC, ASN, AOQ and ATI curves, concepts of Producer's and Consumer's risks, AQL, LTPD and AOQL,
UNIT IV	Sampling plans for inspection by variables, Use of Dodge-Roming tables.
REFERENCES	D.C. Montgomery. (2009): Introduction to Statistical Quality Control. Wiley. Wetherill, G.B. Brown, D.W.(1991): Statistical Process Control Theory and Practice, Chapman & Hall. Ott, E. R.(1977): Process Quality Control (McGraw Hill) Wetherill, G.B.(1977): Sampling Inspection and Quality control, Halsteed Press. Duncan A.J.(1974): Quality Control and Industrial Statistics, IV Edition, Taraporewala and Sons.

B060905T: PSYCHOLOGICAL STATISTICS **Credit: 4**

Course Objective: The objective of this course is to impart necessary knowledge about the use of statistical tools and techniques for psychological measurement.

Learning Outcomes: After the successful completion of this course the student shall be able to:

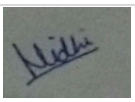
- Acquire knowledge about the use of statistical methods in psychology
- Have deeper understanding of the psychometric assessments and
- Assimilate information by analyzing psychometric data



UNIT I	Methods of Standardisation of scales and tests, Scaling procedures: Z-scores, standard scores, T-scores, percentile scores, equivalent scores
UNIT II	Intelligence quotient, its measurement and uses, Attitude scaling procedures
UNIT III	Test theory, Linear model of test theory, reliability of test scores and its determination, effect of length of test on test reliability, practical methods of estimating test reliability: test retest method, method of rational equivalence (Kuder-Richardson method), parallel test method, split –half method,
UNIT IV	Test Validity and its types, effect of length of test on test validity, use of factor analysis and path analysis in psychometry
REFERENCES	Garett H, Statistics in Psychology and Education Privitera G. J. (2015) Essential Statistics for the Behavioral Sciences Aron, Aron, & Coups, Statistics for Psychology Frederick Gravetter & Larry B. Wallnau , Essentials of Statistics for the Behavioral Sciences, 7th Edition

B060906P: PRACTICAL/LAB **Credit: 4**

Based on theory papers of Third semester.



SEMESTER IV

B061001T: APPLIED REGRESSION ANALYSIS **Credit: 4**

Course Objective: To conceptually understand the use of multiple linear regression models for statistical inference.

Learning Outcomes: The student after completing this course shall be able to:

- Have a solid foundation in Statistical Theory and Regression Modeling
- Apply these methods to real world problems and
- Draw valid conclusions

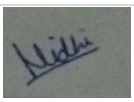
UNIT I	Basic Fundamental Concepts Of Modeling; Regression Model , Residuals and their analysis, Influential observations, Power transformations for dependent and independent variables
UNIT II	Robust regression, L-1 norm, Estimation of Prediction error by cross-validation and boot strap
UNIT III	Non-linear regression models, different methods of estimation (Least square & Maximum Likelihood), Asymptotic properties of estimators
UNIT IV	Generalised Linear models, Analysis of Binary and Grouped data by using Logistic models, Log0Linear models
REFERENCES	Sprent, P. (1999). Applied Regression Analysis. Cook & Weisberg, Residuals & Inferences in Regression (Chapman & Hall) John F. Monahan,A Primer on Linear Models, CRC Press, 2008. Douglas C. Montgomery,Elizabeth A.Peck and G. Geoffrey Vining: Introduction to Linear Regression Analysis, Wiley, 2001. Norman R. Draper and Harry Smith: Applied Regression Analysis, Wiley, 1998. C.R. Rao, H. Toutenburg,Shalabh and C. Heumann: Linear Models and Generalizations - Least Squares and Alternatives,Springer, 2008

B061002T: STOCHASTIC PROCESS **Credit: 4**

Course Objective: The objective of this course is to familiarize students with the various probability models for stochastic processes.

Learning Outcomes: After the successful completion of this course the students shall be able to:

- Understand the theory and applications of random processes
- Get familiar with the broad range of mathematical and computational tools apt for stochastic processes
- Apply the tools for the analysis of stochastic processes



UNIT I	Stochastic process: its introduction, classification, discrete/continuous spaces, types of stochastic processes with elementary problems
UNIT II	Markov chains: definition & examples, Kolmogorov's equations, Calculation of n-step transition probability matrix & its limit, stationary distribution, classification of states, transient markov chain
UNIT III	Random walk and Gambler's ruin problem, Ideas of branching process, poisson process,
UNIT IV	pure birth process, pure death process, Birth & death processes:applications from social, physical and biological sciences
REFERENCES	Parzen, E. (1999). *Stochastic processes*. Society for Industrial and Applied Mathematics. Medhi, J. (1994). *Stochastic processes*. New Age International. Hoel, P. G., Port, S. C., & Stone, C. J. (1986). *Introduction to stochastic processes*. Waveland Press. Karr, A. F. (1984). Stochastic processes (Sheldon M. Ross). *SIAM Review*, *26*(3), 448. Karlin, S. (2014). *A first course in stochastic processes*. Academic press. Bhat, B. R. (2004). *Stochastic models: analysis and applications*. New Age International. Basu A.K. (2003).Introduction to Stochastic Processes, Narosa Publishing House. Feller, W. (1968): Introduction to Probability and its Applications, Vol.1, Wiley Eastern. Medhi, J, (1982): Stochastic Processes, Wiley Eastern. Suddhendu Biswas (1995). Applied Stochastic Processes: A Biostatistical and Population oriented Approach, Wiley Eastern. Bhat B.R. (2008) Stochastic Models: Analysis and Applications, New Age Publshers Karlin, S. and Taylor,H.M.(1998) An Introduction to Stochastic Modelling, Edition 3, Academic Press

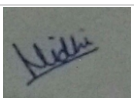
B061003T: BIOSTATISTICS **Credit: 4**

Course Objective: The objective of this course is to impart the students the necessary foundation on the application of statistical methods in biological and health sciences.

Learning Outcomes: After the successful completion of this course the students shall be able to:

- Develop and understanding of data related to public health and its measurement
- Perform statistical analysis on data pertaining to public health

UNIT I	Measuring the occurrence of disease, Measures of morbidity - prevalence and incidence rate, association between prevalence and incidence, uses of



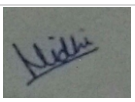
	prevalence and incidence, problems with incidence and prevalence measurements; Clinical agreement: kappa statistics, Mantel-Haenszel test; intra-class correlation
UNIT II	Assessing the validity and reliability of diagnostic and screening test: Validity of screening test – sensitivity, specificity, positive predictive value and negative predictive value; Reliability; Relationship between validity and reliability; ROC curve and its applications; Overall accuracy
UNIT III	Association; causation; causal inference; Errors and bias; Confounding; Controlling confounding; Measurement of interactions; Generalizability Estimating risk: Estimating association – absolute risk, relative risk, odds ratio
UNIT IV	Estimating potential for prevention – attributable risk; comparison of relative risk and attributable risk; Odds ratios for retrospective studies; Odds ratios approximating the prospective RR; Exact inference for odds ratio analysis of matched case-control data
REFERENCES	Rossi R.J.(2010).Applied Biostatistics for Health Sciences, Wiley Pullum W. 2006. An Assessment of Age and Data Reporting in the DHS Surveys, 1985-2003. DHS Methodological Report No. 5. Calverton, Maryland, Marco International Inc. Royce A. Singleton and Bruce C. Straits, (1999): Approaches to Social Research, Oxford, Oxford University Press. Young P V. 1994. Scientific Social Surveys and Research. Prentice-Hall, New York (4th Edition). Altman D G: Practical Statistics for Medical Research, London: Chapman and Hall, 2006. Rosner B: Fundamentals of Biostatistics, ed. 6, 2006. Dunn G, Everitt B: Clinical Biostatistics: An Introduction to Evidence-based Medicine. Edward Arnold, 1995.

B061004T: ACTUARIAL STATISTICS **Credit: 4**

Course Objective: This area belongs to Applied Statistics concerning itself with the application of statistical methods to insurance and risk management sectors. The course focuses on basic terminologies and principles related to actuarial science.

Learning Outcomes: After successful completion of this course the students shall be able to:

- Understand different types of insurance and acquire the knowledge of different related lifetime random variables
- Explain the concept of survival models
- Describe estimation procedures for lifetime distributions.
- Describe the main methods of projecting/forecasting mortality rates.



- Understand and discuss the ethical dimensions and implications of the modelling introduced in the course.

UNIT I	Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory, models for individual claims and their sums.
UNIT II	Survival function, Uncertainty of age at death, time until-death for a person, curate future lifetime, force of mortality. Life table and its relation with survival function, life table characteristics, assumptions for fractional ages, some analytical laws of mortality, select and ultimate life table
UNIT III	Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.
UNIT IV	Life insurance: Insurance payable at the moment of death and at the end of the year of death level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities. Net single premiums, Factor affecting mortality and selections.
REFERENCES	Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics. Society of Actuaries, Itasca, Illinois, U.S.A. Daykin, C. D., Pentikainen, T. and Pesonen, M. (1993). Practical Risk Theory for Actuaries. Chapman & Hall/CRC. Deshmukh, S.R. (2009). Actuarial Statistics: An Introduction Using R, University Press, India. Dickson, C. M. D. (2005). Insurance Risk and Ruin (International Series no.1 Actuarial Science), Cambridge University Press. Klugman,S. A., Panjer, H. H., and Willmotand, G. E. (2019). Loss Models: From Data to Decisions. Willy publication. Neill, A. (1977). Life Contingencies, Heinemann. Rotar, V.I. (2015). Actuarial Models: The Mathematics of Insurance, 2nd ed., CRC Press, New York. Spurgeon, E.T. (1972). Life Contingencies, Cambridge University Press.

B061005T: STATISTICAL ANALYSIS USING SPSS **Credit: 4**

Course Objective: The objective of this course is to acquaint the students with SPSS software and its use in statistical analysis.

Course Outcome: After the successful completion of the course the students shall be able to:

- Understand SPSS environment and the available in-built statistical tools
- Utilize SPSS software for data visualization and
- Perform statistical analysis using SPSS

UNIT I	Knowledge and familiarity with statistical package SPSS, The Fundamental Mechanics of SPSS, Getting Data into and out of SPSS, Graphical representation of data, Tabulation of data, Descriptive Statistics, Summarizing Data, Creating & Editing Charts, Modifying data values, Sorting & Selecting Data Values, Chi- Square and t- test.
UNIT II	Advance features of SPSS, Correlation & Regression, One-way ANOVA, Factorial ANOVA,
UNIT III	Nonparametric Tests,
UNIT IV	Discriminant Analysis, Factor Analysis, Cluster Analysis.
REFERENCES	Field A., Discovering Statistics Using SPSS Argyrous, G. (2012), Statistics for Research: With a Guide to SPSS, Sage South Asia; Third Edition. George Darren: SPSS for Window Step by Step. Griffith, A. (2007), SPSS For Dummies, Published by Wiley Publishing, Inc. Patric L. . A. K. and Feeney B. C.: A Simple Guide to SPSS.

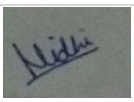
B061006T: C PROGRAMMING **Credit: 4**

Course Objective: The objective of this course is to inculcate in students the basic programming skills using C-language.

Learning Outcomes: After the successful completion of this course the students shall be able to:

- Understand the syntax of C-programming language
- Write basic programs in C-language

UNIT I	Introduction, C-character set, constants, variables, key words, C-instructions: type declarations, arithmetic, integers and float conversions. Types of conversions in assignment, hierarchy of operations



UNIT II	Decision control structures: if statement, if-else statement, nested if else statement
UNIT III	Use of logical operators, hierarchy of logical operations and conditional operators
UNIT IV	Functions and parameters, input/output, control statements-switch for, while, do-while, break & continue statements, exit functions Pointers and references, arrays and character strings
REFERENCES	Kanetkar Y.P., Let Us C, 18 th edition Gottfried, Byron, Theory and Problems of programming with C (TMH) Schildt Herbert, C-The Complete Reference, III ed (TMH) Schildt Herbert, C-Made Easy (McGraw Hill)

B061007P: PRACTICAL/LAB **Credit: 4**

Based on theory papers of Fourth semester.

B061008R: RESEARCH PROJECT DISSERTATION IV SEMESTER **Credit: 4+4**

Dissertation will include: a) Review of the relevant literature, b) Objectives of the study, c) Materials and Methods, d) Results/Observations (supported by figures/tables etc as required), e) Discussion of the Results/Observations, f) Summary and g) References

Note: More thrust on research related to the topics related to Indian Knowledge System.