

**SYLLABUS**  
**STATISTICS**  
**FOR**  
**4 YEARS U.G (HONOURS) PROGRAMME**  
**4 YEARS U.G (HONOURS WITH RESEARCH) PROGRAMME**  
**AND**  
**P.G. PROGRAMME**  
**EFFECTIVE FROM SESSION 2024-25 ONWARDS**



**MAHARAJA SUHEL DEV UNIVERSITY**  
**AZAMGARH (U. P.)-276128, INDIA**

**PREPARED BY**  
**PROF. MOHD. SADIQ KHAN**  
**PROFESSOR**  
**DEPARTMENT OF STATISTICS**  
**SHIBLI NATIONAL COLLEGE, AZAMGARH. (U.P.)**

**CONVENER OF STATISTICS**  
**MAHARAJA SUHEL DEV UNIVERSITY**  
**AZAMGARH (U. P.)-276128, INDIA**

*MSK*

*Prof. Mohd. Sadiq Khan*

*[Signature]*

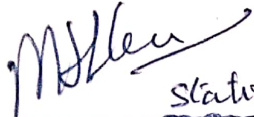
## Resolution

The meeting of Board of Studies (BOS) of STATISTICS was held on 14.10.2024 to consider and approve the NEP-2020 Framework & choice based credit systems Syllabus developed in accordance with G.O. शासनादेश संख्या-2000/संतर-3-2024-0901/2023(स4) दिनांक-02.09.2024

The following were present in the above said meeting:

S. No.	Name	Designation	Capacity
1	PROF. HIMANSHU PANDEY PROFESSOR, DEPT. OF STATISTICS, DDU GORAKHPUR UNIVERSITY, GORAKHPUR	PROFESSOR	EXTERNAL EXPERT
2	PROF. MANOJ KUMAR SRIVASTAV DEPT. OF MATHEMATICS, T.D. P.G. COLLEGE, JAUNPUR.	PROFESSOR	EXTERNAL EXPERT
3	PROF. MOHD. SADIQ KHAN DEPT. OF MATHEMATICS SHIBLI NATIONAL COLLEGE, AZAMGARH.	PROFESSOR	CONVENOR (STATISTICS)
4	DR.NAFIS AHMAD DEPT. OF MATHEMATICS SHIBLI NATIONAL COLLEGE, AZAMGARH.	ASSOCIATE PROFESSOR	MEMBER
5	DR. P.C. SRIVASTAV DEPT. OF MATHEMATICS D.A.V. PG COLLEGE, AZAMGARH.	ASSOCIATE PROFESSOR	MEMBER
6	DR.SERAJ AHMAD KHAN DEPT. OF MATHEMATICS SHIBLI NATIONAL COLLEGE, AZAMGARH	ASSISTANT PROFESSOR	MEMBER

After detailed discussion, the BOARD OF STUDIES of Dt.14.10.2024 have unanimously approved the proposed Framework & Syllabus Statistics and recommended that it may be implemented in accordance with above said G. O. under National Education Policy 2020.

  
(CONVENOR OF STATISTICS)

(EXTERNAL EXPERT)

(EXTERNAL EXPERT)

  
(MEMBER)

(MEMBER)

  
(MEMBER)

4<sup>th</sup> YEAR UG (HONS.) / 4<sup>th</sup> YEAR UG (HONS. WITH RESEARCH) \*\* / M.A./M.Sc. (STATISTICS)

YEAR	SEM.	CATEGORY/TYP E OF THE COURSE	COURSE CODE	PAPER TITLE	THEORY /PRACTICA L	CRED IT	
4 <sup>th</sup> YEAR UG (HONS.) / 4 <sup>th</sup> YEAR UG (HONS. WITH RESEARCH) / M.A. (1 <sup>st</sup> YEAR) / P.G. DIPLOMA	VII	MAJOR (COMPULSORY)	B060701T	Optimization Techniques	THEORY	4	
			B060702T	Probability Theory	THEORY	4	
			B060703T	PROGRAMMING IN R (Lab. Based)	THEORY	4	
		MAJOR (OPTIONAL)	OPTIONAL PAPERS	CHOOSE ANY ONE OF THE FOLLOWING			
		B060704T	(A) Linear Algebra & Matrix Theory OR	THEORY	4		
		B060705T	(B) Statistical Quality Control				
	PRACTICAL (COMPULSORY)	B060706P	Stat Practical Lab-1 Based on Stat- B060701T B060702T and B060703T (based on Calculator, Excel & R Programming as per suitability)	Practical	4		
	VIII	MAJOR (COMPULSORY)	B060801T	Theory of Estimation	THEORY	4	
			B060802T	Sampling Theory	THEORY	4	
			B060803T	Stochastic Processes	THEORY	4	
		MAJOR (OPTIONAL)	OPTIONAL PAPERS	CHOOSE ANY ONE OF THE FOLLOWING			
		B060804T	(A) Survival Analysis OR	THEORY	4		
		B060805T	(B) Decision Theory				
PRACTICAL (COMPULSORY)	B060806P	Stat Practical Lab-2 Based on Stat- B060801T B060802T and B060803T (based on Calculator, Excel & R Programming as per suitability)	PRACTICAL	4			

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M.A. (STATISTICS) SECOND YEAR

YEAR	SEM.	CATEGORY/TYP E OF THE COURSE	COURSE CODE	PAPER TITLE	THEORY/ PRACTICAL	CRED IT	
M.A. SECOND YEAR	IX	MAJOR (COMPULSORY)	B060901T	Multivariate Statistical Analysis	THEORY	4	
			B060902T	Testing of Statistical Hypotheses	THEORY	4	
		MAJOR (OPTIONAL)	OPTIONAL	CHOOSE ANY ONE OF THE FOLLOWING			
			B060903T B060904T	(A) Queuing & Inventory Theory OR (B) Statistical Data Mining Methods	THEORY	4	
		PRACTICAL (COMPULSORY)	B060905P	Stat Practical Lab-3 Based on Stat- B060901T and B060902T (based on Calculator, Excel & R Programming as per suitability)	Practical	4	
		RESEARCH PROJECT	B060906R	RESEARCH PROJECT (STATISTICS)	PROJECT/ Dissertation	4	
		X	MAJOR (COMPULSORY)	B0601001T	1. Actuarial Statistics	THEORY	4
			OPTIONAL GROUPS	OPTIONAL PAPERS	CHOOSE ANY ONE OF THE FOLLOWING GROUP		
	GROUP - A		B0601002T	2. Data Analysis Using Statistical Packages	THEORY	4	
			B0601003T	3. Time Series Analysis	THEORY	4	
	GROUP - B		B0601004T	2. Econometrics	THEORY	4	
			B0601005T	3. Statistics for Managers	THEORY	4	
	GROUP - C		B0601006T	2. Demographic Techniques	THEORY	4	
			B0601007T	3. BAYESIAN INFERENCE	THEORY	4	
	RESEARCH PROJECT	B0601008T	RESEARCH PROJECT (STATISTICS)	PROJECT/ Dissertation	4		

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## OPTIMIZATION TECHNIQUES

**Unit I**

Mathematical Programming - Solving of LPP by graphical method - Linear Programming Problem (LPP)–Simplex, Big M and Two Phase methods – Revised simplex method – Solving LPP using Duality - Dual Simplex method

**Unit-II**

Post Optimality and Sensitivity Analysis–Variation in cost vector and requirement vector– Addition and deletion of single variable and single constraint - Integer Programming Problem (IPP) - Gomory's cutting plane algorithm– Mixed IPP – Branch and Bound technique

**Unit III**

Dynamic programming problem (DPP) - Bellman's principle of optimality - General formulation - computation methods and application of DPP - Solving LPP through DPP approach

**Unit IV**

Non Linear Programming: Constrained and Unconstrained Problems of Maxima and minima, Constraints in the form of equations (Lagrangian Method) and in equations (Kuhn-Tucker conditions), Quadratic programming: Beale's and wolf's methods simplex method for quadratic programming.

**Unit- V**



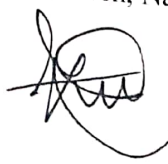
PERT - CPM: Applications, Basic Steps in PERT/CPM techniques; Time estimates and Critical Path in Network Analysis; Optimum and minimum duration cost, PERT, Resource Allocations.

**Text Books**

1. Hillier FS and LibermannGJ(2002):IntroductiontoOperationsResearch,7<sup>th</sup> Edition, McGraw Hill
2. KantiSwarup,P.K.GuptaandManMohan(2004):OperationsResearch,SultanChand and Sons, New Delhi.
3. Gross D, Shortle J.F. , Thompson J.M. and Harris C.M. (2011): Fundamentals of Queuing Theory, John Wiley & Sons

**Reference Books**

1. Sinha SM(2006):Mathematical Programming: Theory and Methods, Elsevier Publications.
2. Devi Prasad (2015), Operations Research, Narosa Publishing House
3. Kapoor V.K.(2008):Operations Research, 8/e,SultanChand&Sons
4. Sharma .S.D(1999): Operation Research , Kedar Nath RamNath & Co., Meerut.
5. Hamdy A.Taha(1987):Operations Research – An Introduction, 4/e, Prentice Hall of India, PrivateLtd,NewDelhi.
6. Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House
7. K. Chandrasekhara Rao and Shanti Lata Misra (2012), Operations Research, Narosa Publishing House

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**PROBABILITY THEORY****Unit I**

Algebra of sets - fields and sigma-fields, Inverse function – Measurable function – Probability measure on a sigma field – simple properties - Probability space - Random variables and Random vectors – Induced Probability space – Distribution functions – Decomposition of distribution functions.

**Unit II**

Expectation and moments – definitions and simple properties – Moment inequalities – Holder, Jensen, Chebyshev, Markov Inequalities– Characteristic function – definition and properties – Inversion formula.

**Unit III**

Convergence of a sequence of random variables - convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean - Weak convergence of distribution functions – Slutsky theorem - Helly-Bray theorem.

**Unit IV**

Definition of product space – Fubini's theorem (statement only) - Independence of two events – Independence of classes – Independence of random variables – properties – Borel zero –one law.

**Unit V**

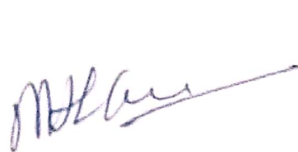
Law of large numbers - Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (statement only) – Central Limit Theorem – Lindeberg – Levy theorem, Linderberg – Feller theorem (statement only), Liapounov theorem – Relation between Liapounov and Linderberg – Feller forms – Radon Nikodym theorem and derivative (without proof) – Conditional expectation – definition and simple properties.

**Books for Study**

1. Bhat, B. R. (2007): Modern Probability Theory, 3<sup>rd</sup> edition, New Age International Pvt. Ltd.
2. Ash, R.B. (1972): Real Analysis and Probability, Academic Press.
3. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley

**Books for Reference**

1. Athreya K B and Lahiri S N (2005): Measure Theory, Hindustan Book Agency.
2. Tucker, H.G. (1967): A Graduate course in Probability, Academic Press.
3. Burill, C.W. (1972): Measure, Integration and Probability, McGraw Hill.
4. Chow, Y.S. and Teicher, H. (1979): Probability Theory, Springer.
5. Loeve, M. (1985). Probability Theory, 3<sup>rd</sup> edition, Springer..
6. Resnick S.I. (2001): A Probability Path, Birkhauser.
7. Basu A K, and A Bandopadhyay (2012): Measure Theory and Probability, PHI Learning Pvt. Ltd.





## PROGRAMMING IN R (Lab. Based)

**Unit I**

R language Essentials: Expressions and objects, Assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection ; examples.

**Unit II**

R Programming: conditional statements – if and if else; loops – for, while, do-while; functions – built-in and user defined; Data entry – reading from text file, data editor; examples.

**Unit III**

Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises.

**Unit IV**

Probability and Distributions: Random sampling and combinatory; obtaining density, cumulative density and quantile values for discrete and continuous distributions; generating samples from discrete and continuous distributions; Plotting density and cumulative density curves; Q-Q plot.

**Unit V**

Correlation: Pearson, Spearman and Kendall's correlation; Regression – fitting, obtaining residuals and fitted values; one and two sample tests for mean and variance – one way and two way ANOVA.

**Books for Study**

1. Michael J. Crawley (2007), The R Book, John Wiley and Sons Ltd.
2. Peter Dalgaard (2008), Introductory Statistics with R, 2<sup>nd</sup> edition, Springer.

**Lab Exercises:**

1. Operations on vectors and matrices
2. Creating and manipulating data frames.
3. Writing user defined functions for finding arithmetic mean, median, factorial, matrix addition and multiplication.
4. Bar and Pie charts.
5. Box plots for single and multiple groups.
6. Density and cumulative density plots for Binomial, Poisson, Normal and exponential distributions.
7. Checking Normality using Histogram and Q-Q plot.
8. Correlation coefficient – Pearson's, Spearman and Kendall's Tau.
9. Fitting simple linear and multiple linear regressions.
10. One sample and two sample t test.
11. One way and two ways ANOVA.





## LINEAR ALGEBRA AND MATRIX THEORY

### Unit I

Vector Spaces, Sub-spaces, Basis of a vector space – Vector spaces with inner products  
Gram-Schmidt orthogonalization.

### Unit II

Linear transformation (LT) – Properties – Matrix of a linear transformation – Matrix of composite transformation – Matrix of an inverse transformation – Change of basis  
Orthogonal transformation - Dual space.

### Unit III

Linear equations – Solution space and null space – Sylvester's law of nullity – Generalized inverse of a matrix – Moore – Penrose inverse

### Unit IV

Eigen values and Eigen vectors of an LT – left Eigen vectors, right Eigen vectors,  
Diagonalizable LT – Lambda matrix, Composition of lambda matrices, Operator polynomial,  
Cayley-Hamilton theorem and minimal polynomial for an LT – Eigen values of matrix  
polynomials.

### Unit V

Bilinear forms Canonical reduction – Sylvester's law of inertia-Definitions of quadratic form  
Lagrange's reduction – Kronecker's reduction Reduction involving the Eigen values of the  
matrix, Generalized Eigen value problem.

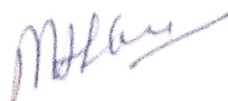
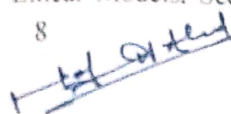
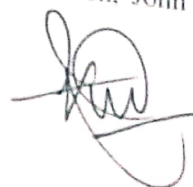
### Books for Study

Biswas S. (2012), Text book of Matrix Algebra, Third Edition, PHI Learning Private Limited, New Delhi.

1. Bhattacharya P.B., Jain S.K., Nagpaul S.K. (2012), First Course in Linear Algebra, New Age International (P) Ltd, New Delhi.
2. Parashar B.P. (1989), Linear Algebra, CBS Publishers and Distributors, Delhi.
3. Rao C.R. (2009), Linear Statistical Inference and its Applications, Second Edition, John Wiley and Sons

### Books for Reference

1. Friedberg S.H., Insel A.J. and Spence L.E. (2014), Linear Algebra, Pearson Education.
2. Gilbert J. and Gilbert L. (2005), Linear Algebra and Matrix Theory. Academic Press.
3. Lipschutz S. and Lipson M. (2009), Schaum's outlines, Linear Algebra, Fourth Edition, McGraw Hill Company.
4. Rao A.R. and Bhimasankaram P. (2000), Linear Algebra, Hindustan.
5. Searle S.R. and Khuri A.I. (2017), Matrix Algebra useful for Statistics, Second Edition, John Wiley and Sons, New Jersey.
6. Searle S.R. and Gruber MHI (2016), Linear Models, Second Edition, John Wiley and



STATISTICAL QUALITY CONTROL

Unit I

Modified control charts for mean – CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling's  $T^2$  control charts and Economic design of X-bar chart

Unit II

Process Capability analysis: Meaning, Estimation technique for capability of a process – Capability Indices: Process capability ratios  $C_p$ ,  $C_{pk}$ ,  $C_{pm}$ ,  $C_{mk}$ ,  $C_{pc}$  – Process capability analysis using a control chart – Process capability analysis using design of experiments

Unit III

Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves – MILSTD -105E Tables

Unit IV

Acceptance sampling variables for process parameter – Sequential plans for process parameter ( $\sigma$  known and unknown) – Sampling variables for proportion non-conforming -  $\bar{X}$  method, K method –

Unit V

Double specification limits – M-method, Double sampling by variables - MILSTD -414 Tables – Continuous Sampling plan – CSP-1, CSP-2, CSP-3, Wald and Wolfowitz SP-A and SP- B

Text Books

1. Douglas C. Montgomery (2009): Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis
3. Oakland, J.S.(1989): "Total Quality Management", Butterworth–Heinemann Ltd., Oxford

Reference Books

1. Mittage, H.J and Rinne, H(1993): Statistical Methods of Quality Assurance, Chapman Hall, London, UK
2. Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.
3. Juran J.M and Frank M.Gryna Jr .(1982): "Quality Planning and Analysis", TMH, India.



STATISTICAL LABORATORY – I

(Based on Stat- B060701T B060702T and B060703T) (Based on Calculator, Excel & R Programming as per suitability)

I. Optimization Techniques (25 marks)

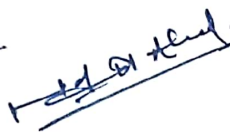
1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean,
8. Interval estimation - difference of means,
9. Interval estimation - variance and ratio of variances.

II. Probability Theory (25 marks)

1. Simple random sampling methods of drawing sample – Estimation of the population total and variance estimation.
2. PPSWR – Hurwitz Thompson estimator - Des Raj ordered estimator – Murthy's unordered estimator – Midzuno scheme.
3. Linear and circular systematic sampling.
4. Stratified sampling – SRS, PPSWR, PPSWOR
5. Cluster sampling – of equal sizes.
6. Ratio, Regression and Difference estimation estimators.

III Distribution Theory (25 marks)

1. Fitting of Multiple linear regression model
2. Residual Analysis for model adequacy, detection of outliers and influential observations
3. Variable Selection procedures
4. Collinearity Diagnostics



**THEORY OF ESTIMATION****Unit I**

Parametric point estimation – properties of estimators – Consistency and its different forms  
Sufficient condition for consistency- Unbiasedness – sufficient statistics – Factorization  
theorem – Distributions admitting sufficient statistic – Exponential and Pitman families  
procedure for finding minimal sufficient statistic.

**Unit II**

The information measure – Cramer – Rao (CR) inequality – Chapman – Robbins (KCR)  
inequality (single parameter case only) – Bhattacharya inequality (single parameter case  
only) – minimum variance bound estimator- Invariant (equivariant) estimators (concepts  
only)

**Unit III**

Uniformly minimum variance unbiased estimators (UMVUE)- condition for the existence of  
UMVUE- Completeness and Bounded completeness- Relation between complete statistic and  
minimal sufficient statistic- Rao – Blackwell Theorem- Lehmann – Scheffe's theorem.

**Unit IV**

Methods of estimation – method of moments and its properties – method of maximum  
likelihood and its properties-Large sample properties of MLE - Method of minimum chi-  
square and its properties – Methods of least squares

**Unit V**

Interval estimation – Pivotal method of construction – shortest confidence intervals and their  
construction (minimum average width) – Construction of shortest confidence intervals in  
large samples. Decision Theory: Simple problems involving quadratic error loss function –  
Elementary notions of minimax estimation – Simple illustrations.

**Books for Study**

1. Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi.
2. Casella, G. and Berger, R.L. (2002):Statistical Inference, Duxubury Process, Belmont, USA.
3. Rohatgi, V.K. (2003): Statistical Inference, Dover Publications, New York.

**Books for Reference**

1. Lehmann, E.L and Casella G(1998) :Theory of Point Estimation, 2/e, Wiley Eastern Ltd.
2. B.K.Kale and K.Muralidharan (2015), Parametric Inference – An Introduction, Narosa Publishing House
3. Kale, B.K. (1999): A First course on Parametric Inference , Narosa Publishing House.
4. Zacks,S. (1981): Parametric Statistical Inference, John Wiley, NY.
5. Srivastava, Khan and Srivastava (2014), Statistical Inference: Theory of Estimation, PHI, India





**SAMPLING THEORY****Unit I**

Preliminaries – Sampling Designs – Simple random sampling– Stratified Random Sampling – Allocation problems – Systematic Sampling Schemes – Linear, Circular, Balanced and Modified systematic sampling methods

**Unit II**

Probability Proportional to size sampling- Inclusion Probabilities – Horvitz-Thompson estimator – Yates –Grundy Form –Midzuno Sampling design – PPSWOR- Des-Raj's Ordered estimator – Murty's unordered estimators

**Unit III**

Ratio estimators and their properties in Simple Random Sampling – Ratio estimators in Stratified Random sampling – Regression Estimators, Regression estimators in Stratified Random Sampling – Multivariate Ratio estimators and Multivariate Regression Estimators

**Unit IV**

Cluster Sampling: Equal cluster sampling – Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance – Two stage sampling – variance of the estimated mean – Double Sampling for stratification and Ratio estimation

**Unit V**

Randomized response methods – Warner's, Simmon's and Two Stage response methods – Sources of errors in Surveys – Mathematical model for the effects of call-backs and the errors of measurement

**Books for Study**

1. Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley Eastern Ltd.,
2. Gupta, A. K. and Kabe D.G. (2011): Theory of Sample Surveys, World Scientific Publishing Co. Pte. Ltd., Singapore
3. Singh, D. and Choudhary, F.S (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.,
4. Sukhatme PV. Etal. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and ISARI Publications, New Delhi

**Books for Reference**

1. Desraj and Chandhok P.(1998): Sampling Theory, Narosa Publications, New Delhi
2. Kish, L(1995) : Survey Sampling, John Wiley and Sons.
3. Murthy, M.N (1979): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
5. Sarjinder Singh (2004): Advanced Sampling – Theory with Applications, Kluwer Publications

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## STOCHASTIC PROCESSES

## Unit I

*Stochastic processes:* Definition and classification – Markov chain– Examples (Random walk, Gambler's ruin problem)- Transition Probability Matrices - Higher Transition Probabilities -Bernoulli Trails - classification of states and chains - theorems and problems; Basic limit theorem of renewal theory.

## Unit II

*Poisson Process:* Overview- postulates- probability mass function -Properties - inter related probability distributions- Generalization- Arrival process, Departure Process, Pure Birth(Yule-Furry) process, Birth and Death Processes, Birth-Death and Migrations processes- Chapman Kolmogorov Equations- Compound Poisson Process - Transition density matrix and Poisson Process.

## Unit III

*Weiner Process:* Brownian Motion, Joint probabilities, Wiener process, Differential equations, Kolmogorov equations, First passage time distribution; Branching Process: properties of generating functions of branching processes, Probability of Ultimate extinction, Distribution of Total number of Progeny, Age dependent Branching process

## Unit IV

*Renewal processes:* Definition, examples and relationships between terms – renewal interval, delayed recurrent event, Renewal Processes in continuous time, Renewal Function and renewal density, renewal equation, renewal theorems – Study of residual life time process

## Unit V

*Stationary processes and Time Series:* Stationary Processes, second order, stationarity, Gaussian Processes, weakly and strongly stationary process; Time Series- White Noise process, first order Markov process, MA and AR processes, Autoregressive process of order two, ARMA process verification of stationarity.

## Books for Study

1. Karlin, S and Taylor, H.M(1975): A First Course in Stochastic Processes, Academic Press, New York.
2. Medhi,J (2009): Stochastic Processes, 3/e, New age International.
3. Bhat B.R.(2004): Stochastic Models: Analysis and Applications, New Age Publications

## Books for Reference

1. Bhattacharya and Waymire, E.C. (1992): Stochastic Process with Applications John Wiley and sons.
2. Jones,P.W and Smith,P(2001): Stochastic Processes: An Introduction, Arnold Press.
3. Cinlar, E(1975): Introduction to Stochastic Processes, Prentice-Hall Inc., New Jersey.
4. Cox, D.R and Miller, H.D(1983) : Theory of Stochastic Processes – Chapman and Hall, London,Third Edition
5. Ross S.M (1983): Stochastic Process. Wiley.
6. G. Grimmett and D. Stirzaker (2001): Probability and Random Processes, 3/e, OUP Oxford.

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*1-1-2021*

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## SURVIVAL ANALYSIS

**Unit I**

Concepts of time, Order and random Censoring, likelihood in these cases. Life distributions- Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference (Point estimation, scores, MLE)

**Unit II**

Life tables, failure rate, mean residual life and their elementary properties. Concept of Ageing, Types of Ageing classes and their properties and relationship between them, Bathtub Failure rate, Concept of Inverse Hazard rate.

**Unit III**

Estimation of survival function Actuarial Estimator, Kaplan- Meier Estimator, Estimation under the assumption of IFR / DFR. Tests of exponentiality against non- parametric classes- Total time on test, Deshpande test.

**Unit IV**

Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi- parametric regression for failure rate, Cox's proportional hazards(PH) model with one and several covariates and estimation problems in Cox's PH Model. Rank test for the regression coefficients.

**Unit V**

Introduction to Competing risks analysis and estimation problems in competing risk model for parametric and non- parametric semi parametric set up. Ideas of Multiple decrement life table and its applications.

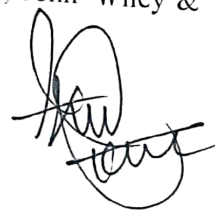
**Books for Study:**

1. Miller, R.G. (1981) : Survival analysis (John Wiley).
2. Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall, New York.
3. Elisha T Lee, John Wenyu Wang and Timothy Wenyu Patt(2003): Statistical Methods for Survival data Analysis, 3/e, Wiley Inter Science.

**Books for Reference:**

1. Gross, A.J. and Clark, V.A. (1975) : Survival distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.
2. Elandt Johnson, R.E. Johnson N.L.: Survival Models and Data Analysis, John Wiley and sons.
3. Kalbfleisch J.D. and Prentice R.L.(1980), The Statistical Analysis of Failure Time Data, JohnWiley.
4. Klelin P. John and Moeschberger(2003): Survival Analysis: Techniques for Censored and Truncated Data, 2/e, Springer.
5. Lawless J.F. (1982) Statistical Models and Methods of Life Time Data; John Wiley & Sons.





## DECISION THEORY

**Unit I**

Basic elements of a decision problem - Randomized and non-randomized decision rules - Estimation and testing of hypothesis as decision problems - Baye's approach to inference and decision -

**Unit II**

Loss functions - Prior and Posterior distributions and its analysis for Bernoulli, Poisson, and normal processes - Decision principles and Baye's risk-

**Unit III**

Utility theory - axioms, construction of utility functions, sufficiency, equivalence of classical and Bayesian sufficiency, complete and essentially complete classes of decision rules

**Unit IV**

Minimax analysis - Basic elements of game theory - General techniques of solving games - Finite games - Supporting and separating hyper plane theorems - Minimax theorem - Minimax estimation for normal and Poisson means

**UNIT V**

Admissibility of Baye's and minimax rules, General theorems on admissibility, Robustness of Baye's rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.

**Text Books:**

1. James O. Berger (1980): Statistical Decision Theory and Bayesian Analysis, Springer Verlag
2. M.H. DeGroot (1970): Optimal Statistical Decisions, John Wiley
3. H. Raiffa and R. Schlaifer (2000): Applied Statistical Decision Theory, Wiley

**Reference Books:**

1. Zellener (1971): An Introduction to Bayesian Inference in Econometrics, Willey
2. Hayes J. G and Winkler R I (1976): Probability, Statistics and Decision, Dower
3. Anthony O' Hangan (1994): Kendall's Advanced theory of Statistics Vol. 2B, Bayesian Inference, John Wiley

*M.H. DeGroot*  
~~James O. Berger~~

*Anthony O' Hangan*

## STATISTICAL LABORATORY – II

(Based on STAT B060801T, STAT B060802T and STAT B060803T) (based on Calculator, Excel & R Programming as per suitability)

## III. Estimation (25 marks)

1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean,
8. Interval estimation - difference of means,
9. Interval estimation - variance and ratio of variances.

## IV. Sampling Theory (25 marks)

1. Simple random sampling methods of drawing sample – Estimation of the population total and variance estimation.
2. PPSWR – Hurwitz Thompson estimator - Des Raj ordered estimator – Murthy's unordered estimator – Midzuno scheme.
3. Linear and circular systematic sampling.
4. Stratified sampling – SRS, PPSWR, PPSWOR
5. Cluster sampling – of equal sizes.
6. Ratio, Regression and Difference estimation estimators.

## III Linear Models and Regression Analysis (25 marks)

5. Fitting of Multiple linear regression model
6. Residual Analysis for model adequacy, detection of outliers and influential observations
7. Variable Selection procedures
8. Collinearity Diagnostics

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## MULTIVARIATE STATISTICAL ANALYSIS

**Unit I**

Multivariate normal distribution – Marginal and conditional distributions – characteristic function. Maximum likelihood estimation of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known

**Unit II**

Total, Partial, Multiple correlation in the Multivariate setup – MLEs of Total, Partial and Multiple correlation coefficients. Sampling distributions of Total and Multiple Correlation in the null case. Hotelling  $T^2$  statistic, derivation and its distribution – Uses of  $T^2$  statistic – relation between  $T^2$  and  $D^2$  – Mahalanobis  $D^2$  statistic and its distribution

**Unit III**

Generalized variance – Wishart distribution (statement only) – Properties of Wishart distribution – Test for covariance matrix – Test for equality of covariance matrices

**Unit IV**

Classification problems – Classification into one of two populations (known and unknown dispersion matrix) – Classification in to one of several populations – Fisher's Linear discriminant function

**Unit V**

Principal components – properties. Extraction of Principal components and their variances Canonical correlation – Estimation of canonical correlation and variates. Factor analysis – Mathematical model- Estimation of Factor Loadings — Concept of factor rotation – Varimax criterion

**Books for Study**

1. Anderson, T.W. (2003) : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2. Johnson, R. A and. Wichern D.W (2007): Applied Multivariate Statistical Analysis, 6 /e, Prentice-Hall of India Private Ltd., New Delhi.
- Giri, N.C(2003): Multivariate Statistical Inference, Academic Press, NY

**Books for Reference**

1. Morrison, F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
2. Rao, C.R(1998): Linear Statistical Inference and its Applications, Wiley Eastern Ltd.,
3. Alvin C. Rencher(2002): Methods of Multivariate Analysis, 2/e, Wiley Interscience
4. Srivastava M.S. and Khatri C.G.( 1979):Introduction to Multivariate Analysis, Elsevier

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## TESTING OF STATISTICAL HYPOTHESES

### Unit I

Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, Most powerful tests, Uniformly most powerful test, Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma and its applications

### Unit II

Unbiasedness for hypothesis testing, Uniformly most powerful unbiased tests, Unbiased tests for one parameter exponential family, Similar test and complete sufficient statistics, Similar tests with Neyman structure, Locally most powerful tests.

### Unit III

Invariant tests, maximal invariants, Uniformly most powerful invariant tests, Consistent tests, Likelihood ratio test, its properties and its asymptotic distribution, Applications of the LR method.

### Unit IV

Non-parametric tests: Goodness of fit test : Chi-square and Kolmogorov Smirnov test - Test for randomness, Wilcoxon Signed rank test – Two sample problem: Kolmogorov-Smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test, Kruskal Wallis test and Friedman's test

### Unit V

Sequential tests: Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications – Determination of the boundary constants – Operating Characteristic and expected sample size of SPRT – Optimum properties of SPRT.

### Books for Study

1. Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi.
2. Lehmann, E.L and Joseph P. Romano (2005): Testing Statistical Hypotheses, 3/e, Springer
3. Rohatgi, V.K.(2003): Statistical Inference, Dover Publications,.
4. Gibbons, J.D. (1985) : Non Parametric Statistical Inference , 2/e , Marckel Decker.

### Books for Reference

1. Casella, G & Berger, R.L (1990):Statistical Inference , Duxubury Press, Belmont. USA
2. Ghosh,B.K(1970): Sequential Tests of Statistical Hypotheses, Addison Wesley.
3. Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
4. Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India





## QUEUEING AND INVENTORY THEORY

### Unit I

*Poisson Queuing Models with single server:* Descriptions of queuing models, Generalized Birth and Death Processes, steady state Birth and death processes- Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/1): ( $\infty$ /FIFO) and (M/M/1): (N/FIFO) Models, simple numerical problems

### Unit II

*Poisson Queuing Models with multiple server:* Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/C): ( $\infty$ /FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, simple numerical problems

### Unit III

*Non Poisson Queuing Models (Erlangian):* Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/Ek/1), (Ek/M/1), simple numerical problems

### UNIT – IV

Scope and notion of Inventory, Terminology, overview on probabilistic & Deterministic Models, optimality issues with Inventory; Deterministic Inventory models with shortages and without shortage. Finding EOQ and other characteristics, Simple Problem

### UNIT – V

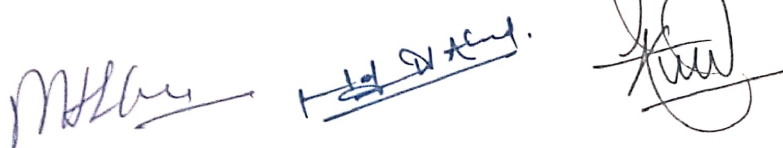
Deterministic Inventory models with simultaneous replenishment and stock clearance, with shortages and without shortages, finding EOQ and other parameters, Simple Numerical Problems; Deterministic Inventory models with Single and multiple price Breaks and numerical examples.

### Books for Study:

1. KantiSwarup et al.: Operations Research, Sultan Chand and Sons, New Delhi
2. S.D Sharma: Operations Research
3. Donald Gross & Carl M Harris (1998): Fundamentals of Queuing theory, John Wiley & Sons, Inc.
4. Hamdy A. Taha (2006): Operations Research – An Introduction, 8/e, Prentice Hall of India Private Ltd., New Delhi

### Books for Reference:

1. Hiller F S and Libermann G J (1995): Introduction to operations Research, 6<sup>th</sup> Edition, McGraw Hill
2. Prabhu N.U. (1965) Applied Stochastic Processes, Mc.Millan
3. J. Medhi (2009). Stochastic Processes. 3/e, New Age International
4. Bhat. B.R. (2002). Stochastic Processes. 2/e, New Age International



## STATISTICAL DATA MINING METHODS

**Unit I**

Introduction to data mining – data types – Measures of similarity and dissimilarity – Data mining tools – supervised and unsupervised learning – Introduction to Cluster Analysis – Types of clustering – Agglomerative Hierarchical clustering algorithm – Issues – strength and weaknesses.

**Unit II**

Basic k-means algorithm – Issues – fuzzy clustering – fuzzy c means algorithm - cluster evaluation – unsupervised and supervised measures - Introduction to classification – Decision Trees – Building a decision tree – Tree induction algorithm – model over fitting – Evaluating the performance of a classifier

**Unit III**

Nearest Neighbor classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression

**Unit IV**

Association rules mining – Basics – Apriori algorithm – Pruning and candidate generation – Rule mining.

**Unit V**

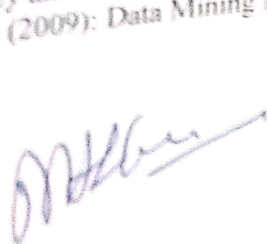
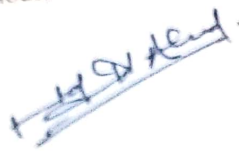
Case studies based on k means clustering - fuzzy c means clustering - kNN classification - Binary logistic regression using R programming language.

**Text Books**

1. Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education, (relevant portions of Chapters 1, 2, 4, 5 and 8).
2. Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd. (relevant portions of Chapter 2)
3. Daniel T. Larose (2006): Data Mining: Methods and Models, John Wiley and sons. (relevant portions of Chapter 4).

**Reference Books**

1. Han, J. and Kamber, M. (2006): Data Mining: Concepts and Techniques, 2<sup>nd</sup> Edition, Morgan Kaufmann Publishers.
2. Paolo Giudici (2003): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley and sons.
3. Rajan Chattamvelli (2009): Data Mining Methods, Narosa Publishing House, New Delhi.


**Unit I**

Basic deterministic model: Cash flows, discount function, interest and discount rates, balances and reserves, internal rate of return, The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.

**Unit II**

Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern reserves, recursion, detailed analysis of an insurance, bases for reserves, non forfeiture values, policies involving a return of the reserve, premium difference and paid-up formula.

**Unit III**

Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves. The general insurance – annuity identity, Select mortality: Select an ultimate tables, Changed in formulas.

**Unit IV**

Multiple life contracts: Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances

**Unit V**

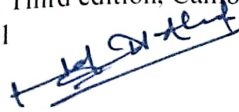
Multiple decrement theory: Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula.

**Text Books**

1. Promislow, S.D(2006): Fundamentals of Actuarial Mathematics, John Willey, Chapters 2- 11 &14.
2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil J. Nesbitt (1997): Actuarial Mathematics, The Society of Actuaries.

**Reference Books**

1. Neill, A. (1977): Life contingencies, Heinemann, London.
2. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
3. Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.
4. Jordan, C.W. Jr. (1967): Life Contingencies, Second edition, Chicago Society of Actuaries.
5. Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
6. Spurgeon, E.T. (1972): Life Contingencies, Third edition, Cambridge University Press.



DATA ANALYSIS USING STATISTICAL PACKAGES

Unit – I

Basic of SPSS – Importing and Exporting of files – Recoding and Computing new variables – Visual Binning – Selection of cases – splitting and merging of files – multiple responses – Graphical plots: Box Plot, Scatter plot, Histogram, Bar and Pie charts.

Unit – II

Fitting of Curves: Parabola, cubic and exponential – correlation and regression: simple, multiple – Rank correlation – Variable Selection in Multiple Regression - Residual Analysis: model adequacy, detection of outliers and influence observations.

Unit – III

Testing of Hypotheses – two sample and paired samples t – test; F-test for two sample variances; Chi-square test for independence of attributes – One way and Two Way Analysis of Variance – Multiple Comparison tests : Tukey's test, Duncan's Multiple range test and Dunnett's test.

Unit – IV

Non-Parametric tests: One sample and Two sample Kolmogorov – Smirnov test, Kruskal – Wallis test, Friedman test, Median Test – One Way MANOVA – Hotelling's  $T^2$  two sample test – Test for two Covariance matrices – One way Repeated Measures ANOVA.

Unit - V

Factor Analysis : Identification of Principle Component, Varimax rotation – Discriminant Analysis – Enter and Stepwise procedures, discriminant scores – Logistic regression – variable selection procedures (Backward and Forward with conditional and wald methods), Odds ratio, Classification matrix –  $2^2$ ,  $2^3$ ,  $3^2$  and  $3^3$  factorial designs – Split Plot designs.

Books for Study

1. Ajai S. Gaur and Sanjaya S Gaur (2009), **Statistical Methods for Practice and Research** - A Guide to Data Analysis Using SPSS, Second Edition, SAGE Publications Pvt. Ltd
2. William E Wagner, III (2010), Using IBM® SPSS® Statistics for Social Statistics and Research Methods, Third Edition, PINE FORGE PRESS, An Imprint of SAGE
3. Robert Ho (2006), Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS, Chapman and Hall, CRC Press

Books for Reference

1. Sarma KVS (2010), Statistics Made Simple – Do It Yourself on PC, Second Edition, PHI Learning.
2. Sabina Landau and Brian S. Everitt (2004), A Handbook of Statistical Analysis using SPSS, Chapman and Hall, CRC Press
3. Andy Field (2009), Discovering Statistics Using SPSS (Introducing Statistical Methods Series), Third Edition, SAGE Publications Ltd.







## TIME SERIES ANALYSIS

**Unit I**

Exploratory Time Series Analysis: Forecasting trend and seasonality based on smoothing. Methods of Exponential and moving average smoothing; Types and implications of interventions; Outliers, additive and innovational outliers, procedure for detecting outliers

**Unit II**

Stationary Stochastic models: weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, Conditions for stationarity and invertibility,

**Unit III**

Models for Time Series: Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods

**Unit IV**

Spectral analysis and decomposition: Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis, Spectral decomposition of weakly AR process and representation as a one-sided MA process – necessary and sufficient conditions, implication in prediction problems.

**Unit V**

Modeling Seasonal Time Series: seasonal ARIMA models, estimation and forecasting, Fitting ARIMA models with Box-Jenkins procedure, Identification, Estimation, Verification, Test for white noise, Forecasting with ARMA models.

**Text Books:**

1. Nicholas T. Thomopoulos, 1980, Applied Forecasting Methods, Prentice Hall
2. BoxGEP, JenkinsGM and ReinselGC (2004): Time Series Analysis – Forecasting and Control, Pearson Education.
3. BrockwellPJ and DavisRA (2002): Introduction to Time Series and Forecasting, Springer.
2. Montgomery D C and Johnson L A (1977): Forecasting and Time Series analysis, McGraw Hill.

**Reference Books:**

1. ChatfieldC (1996): The Analysis of Time Series: Theory and Practice, fifth edition, Chapman and Hall.
2. Nachane D.M. (2006): Econometrics: Theoretical Foundations and Empirical Perspective, Oxford University Press
3. Diggle, P.J Time Series: A Bio-statistical Introduction, Oxford University Press (1990).
4. Hamilton, J., 1994, Time Series Analysis, Princeton University Press.
5. Harvey, A.C., 1993, Time Series Models, MIT Press.
6. Kendall, Sir Maurice and Ord J K (1990): Time Series, Edward Arnold.
7. Tsay, R., 2002, Analysis of Financial Time Series, Wiley Series

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ECONOMETRICS

**Unit I**

Nature and Scope of Econometrics - Review of General Linear Model (GLM), Ordinary Least Squares (OLS), Generalized Least Squares (GLS) and Multicollinearity

**Unit II**

Heteroscedasticity - Autocorrelation, its consequences and tests - Ridge regression - Linear regression with stochastic regressors - Instrumental variable estimation - Errors in variables - Autoregressive linear regression - Distributed lag models.

**Unit III**

Simultaneous linear equations model - Identification problem - Restrictions on structural parameters - rank and order conditions - Restrictions on variances and covariances - Estimation in simultaneous equations model

**Unit IV**

Forecasting - Univariate forecasting methods - Forecasting in regression models - Forecasting with Simultaneous equations model - Evaluation of forecasts - Combination of forecasts

**Unit V**

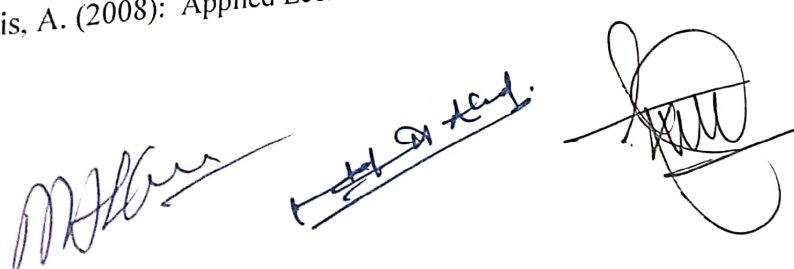
Definition of causality - Granger causality - testing of causality - Co integration, Bivariate co integration tests - multivariate co integration.

**Text Books:**

1. Gujarati, D.N. (2003): Basic Econometrics, McGraw Hill.
2. Johnston, J. (1984): Econometric methods, Third edition, McGraw Hill.
3. Nachane. D.M. (2006): Econometrics: Theoretical Foundations and Empirical Perspective, Oxford University Press.

**Reference Books:**

3. Apte, P.G. (1990): Text book of Econometrics. Tata McGraw Hill.
4. Intrulligator, M.D. (1980): Econometric models - Techniques and Applications, Prentice Hall of India.
5. Kleiber, C. and Zeileis, A. (2008): Applied Econometrics with R, Springer, NY.





STATISTICS FOR MANAGERS

**Unit I**

Concept of Quality – Quality Management – Quality Circles – Total Quality Management – ISO 9001 - Need for SQC in industries – process control – chance and assignable causes of variations – concepts of specification and tolerance limits – process capability – statistical basis for control charts - Six Sigma and lean six sigma.- tools and techniques: DMAIC methodology – DMADV -

**Unit II**

Control chart for variables –  $\bar{X}$  and R chart – simple problems - Control charts for attributes – p, np, c charts – simple problems

**Unit III**

Basics of Experimental design - Principles of design of experiments: Randomization, Replication and local control - determination of experimental units and notion of experimental error – Completely Randomized Design (CRD) – Randomized Block Design (RBD) – Concepts and Simple problems

**Unit IV**

Latin Square Design (LSD) – Concepts and simple problems – Estimating a missing value in RBD and LSD - Multiple comparison tests : Duncan's , Tukey's and Least Significant Difference test

**Unit V**

Factorial Experiments – Concepts -  $2^2$ ,  $2^3$  and  $3^2$  designs – Simple Problems

**Books for Study**

1. Borror.M (2009), The certified quality engineer handbook, 3/e, ASQ quality press, Milwaukee, Wisconsin, USA.
2. Jayachandra M (2001) , Statistical Quality control, CRC press
3. Montgomery.D.C. (2009): Introduction to Statistical Quality Control, 6/e, John Wiley and Sons.
4. Montgomery.D.C. (2013): Design and Analysis of Experiments, 8/e, John Wiley and Sons.
5. Peter W.M.John (1998), Statistical Design and analysis of experiment, SIAM publications

**Books for Reference**

1. Duncan A.J.(1974): Quality Control and Industrial Statistics, 4/e, Taraporewala & Sons.
2. Grant.E.L. and Leavenworth.R.S. (1980): Statistical Quality Control, McGraw Hill.
3. Greg Brue(2003), Design of Six sigma, Tata Mc Graw hill, New Delhi
4. Greg Brue(2002), Design of Six sigma for Managers, Tata Mc Graw hill, New Delhi
5. Amir.D.Aczel and Sounder Pandian (2006): Complete Business Statistics, 6/e, Tata McGraw Hill Publishing Company Limited.

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DEMOGRAPHIC TECHNIQUES

Unit I

Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Labour force participation rates, Density of population, Probability of dying.

Unit II

Life tables: Construction of a life table, Graphs of  $l_x$ ,  $q_x$ ,  $d_x$ , Functions  $L_x$ ,  $T_x$ , and  $E_x$ . Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity.

Unit III

Fertility: Measures of Fertility, Reproductively formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable Populations, Calculation of the age distribution of a stable population, Model Stable Populations.

Unit IV

Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections.

Unit V

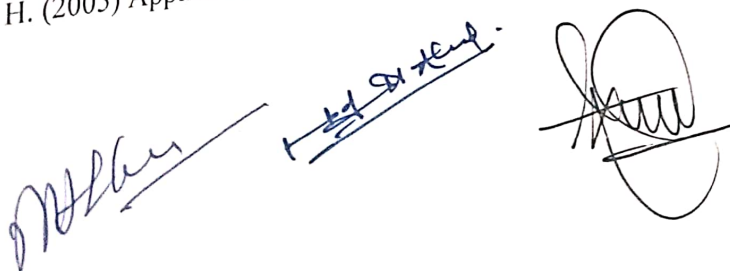
Ageing of the population, Estimation of demographic measures from incomplete data.

Text Books:

1. Pollard, A. H. Yusuf, F. and Pollard, G.N. (1990). Demographic Techniques, Pergamon Press, Chapters 1-8, 12.

Reference Books:

2. Keyfitz, N. (1977) Applied Mathematical Demography A Willey-Interscience Publication.
3. Keyfilz, N. (1968) Introduction to the Mathematic of Population Ready, Mass: Addition-Wesley.
4. Keyfilz, N. and Caswell, H. (2005) Applied Mathematical Demography, Third edition, Springer.



## BAYESIAN INFERENCE

**Unit I**

Introduction about Thomas Baye's-Motivations and Contributions - Evaluation of Subjective probability of an event using a subjectively unbiased coin - Subjective prior distribution of a parameter - Baye's theorem and computation of the posterior distribution.

**Unit II**

Introduction of Prior Distributions, Types of Prior Distributions, Proper Prior-Enlarging the natural conjugate family by enlarging hyper parameter space - mixtures from conjugate family - choosing an appropriate member of conjugate prior family - Non informative, improper and invariant priors - Jeffrey's invariant prior

**Unit III**

Bayesian point estimation: Prediction problem from posterior distribution - Baye's estimators for absolute error loss, squared error loss, linear loss function, Jeffrey's and 0 -1 loss - Generalization to convex loss functions - Evaluation of the estimate in terms of the posterior risk

**Unit IV**

Bayesian interval estimation : Credible intervals - Highest posterior density regions - Interpretation of the confidence coefficient of an interval.

**Unit V**

Bayesian Testing of Hypothesis: Prior and Posterior odds - Baye's factor for various types of testing hypothesis problems -Monte-Carlo Integration and Basic Concepts on Markov chain Monte Carlo techniques (MCMC)(without proof).

**Text Books**

1. Bansal A.K.(2007): Bayesian Parametric Inference, Narosa Publications
2. Sinha S K (1998): Bayesian Estimation, New Age International(P) Ltd, New Delhi

**Reference Books**

2. Berger, J.O.(1985): Statistical Decision Theory and Bayesian Analysis, 2/e, Springer Verlag.
3. Robert C.P. and Casella, G.(2004): Monte Carlo Statistical Methods, 2/e, Springer Verlag.
4. DeGroot, M.H.(2004): Optimal Statistical Decisions, Wiley-InterScience.
5. Gamerman, D. and Lobes H.F. (2000): Stochastic Simulation for Bayesian Inference, Taylor and Francis.
6. Box, G.P. and Tiao, G.C.(1973): Bayesian Inference in Statistical Analysis, Addison - Wesley.

*M. K. Singh*

*Dr. S. K. Singh*

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