# SUMMARY OF THE PROGRAMME


**TWO YEAR POST GRADUATE PROGRAMME IN STATISTICS UNDER C.B.C.S., D.U.**

***(Recommended by B.O.S. in Statistics, D.U. in its meeting held on 11/03/2019 and approved by P.G. Board in its meeting held on …….. and passed by the Academic Council meeting held on ……. and effective from the session …….. )***

**DEPARTMENT OF STATISTICS :: DIBRUGARH UNIVERSITY**

Course Structure of M.A./M.Sc. in Statistics under Choice Based Credit System (CBCS) as approved by the Board of Studies in 11/03/2019 and the Academic Council in its meeting held on …….

The Post Graduate Programme in Statistics shall be of four semesters covering two academic years. A student has to register at least 76 Credits in two academic sessions.

**Course Structure :**

The Course Structure of the Academic Programmes under the CBCS shall be as follows :

**a) Core Courses :** Compulsory components of an Academic Programme. These Courses are to be compulsorily studies as a requirement for the programme. All core Courses shall be of 4 (four) credits each.

**b) Elective Courses :** Elective courses shall be chosen by each student from a pool of courses. The Courses shall be of 4 (four) credits each. The Elective Courses shall be of two kinds as below:

**(i) Discipline Specific Elective (DSE) :** These courses shall be intra-departmental. These courses shall be:

(i) supportive to the discipline of study

(ii) provide an expanded scope

(iii) enable an exposure to some other discipline / domain

(iv) nurture student proficiency / skill

**(ii) Generic Elective (GE) :** These Courses shall be interdepartmental / inter-disciplinary. The students shall have to opt at least 2 (two) courses from other departments according to his/her area of interest.

**c) Ability Enhancement Courses (AEC) :** The Ability Enhancement Courses shall be inter-disciplinary in nature. These courses shall be of 2 (two) credits.

The AECs may be either Ability Enhancement Compulsory Course (AECC) or Skill Enhancement Course (SEC) in nature.

**Besides, there shall be few courses conducted under the UGC's Programmes on Massive Open Online Course (MOOC)s like SWAYAM.**

**The University may from time to time fix relevant criteria for choosing the MOOCs.**

**Distribution of Courses**

| Semester | Courses with Credits | | | | |
|---|---|---|---|---|---|
| | Core (fixed) | Elective (minimum) | | AEC (minimum) | Total |
| | | DSE | GE | | |
| I | 3 Courses X 4 Credits = 12 | 1 Course X 4 Credits = 4 | --- | 1 Course X 2 Credits = 2 | 18 |
| II | 3 Courses X 4 Credits = 12 | 1 Course X 4 Credits = 4 | 1 Course X 4 Credits = 4 | --- | 20 |
| III | 3 Courses X 4 Credits = 12 | 1 Course X 4 Credits = 4 | --- | 1 Course X 2 Credits = 2 | 18 |
| IV | 3 Courses X 4 Credits = 12 | 1 Course X 4 Credits = 4 | 1 Course X 4 Credits = 4 | --- | 20 |

**M. Sc. Programme in Statistics,**
**Dibrugarh University**

| Semester | Course Code | Title of the Course | Type | Credit | CH | | |
|---|---|---|---|---|---|---|---|
| | | | | | L | T / P | Total |
| 1st Sem | C11 | Applied Probability Theory | C | 4 | 3 | 2 | 5 |
| | C12 | Mathematical Analysis and Linear Algebra | C | 4 | 3 | 2 | 5 |
| | C13 | Statistics with Computer | C | 4 | 3 | 2 | 5 |
| | DSE 1 (a) | Industrial Statistics | E | 4 | 3 | 2 | 5 |
| | DSE 1 (b) | Demography | E | 4 | 3 | 2 | 5 |
| | DSE 1 (c) | Operations Research | E | 4 | 3 | 2 | 5 |
| | AEC | Analysis I | E | 2 | 2 | 1 | 3 |
| 2nd Sem. | C21 | Probability Distribution & Reliability | C | 4 | 3 | 2 | 5 |
| | C22 | Estimation Theory | C | 4 | 3 | 2 | 5 |
| | C23 | Regression Analysis | C | 4 | 3 | 2 | 5 |
| | DSE 2 (a) | Quantitative Epidemiology and Biostatistics | E | 4 | 3 | 2 | 5 |
| | DSE 2 (b) | Official Statistics | E | 4 | 3 | 2 | 5 |
| | DSE 2 (c) | Financial Statistics | E | 4 | 3 | 2 | 5 |
| | GE 2 (a) | To opt from sister departments | E | 4 | 3 | 2 | 5 |
| | GE 2 (b) | Statistics – I (To offer to sister Departments) | E | 4 | 3 | 2 | 5 |
| 3rd Sem. | C31 | Testing of Hypotheses | C | 4 | 3 | 2 | 5 |
| | C32 | Non-parametric Inference | C | 4 | 3 | 2 | 5 |
| | C33 | Stochastic Processes | C | 4 | 3 | 2 | 5 |
| | DSE 3(a) | Econometrics | E | 4 | 3 | 2 | 5 |
| | DSE 3(b) | Reliability Engineering | E | 4 | 3 | 2 | 5 |
| | AEC | Analysis II | E | 2 | 2 | 1 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $4^{th}$ Sem. | C41 | Multivariate Methods | C | 4 | 3 | 2 | 5 |
| | C42 | Design & Analysis of Experiments | C | 4 | 3 | 2 | 5 |
| | C43 | Time Series Analysis | C | 4 | 3 | 2 | 5 |
| | DSE 4 (a) | Dissertation | E | 4 | 3 | 2 | 5 |
| | DSE 4 (b) | Bayesian Inference | E | 4 | 3 | 2 | 5 |
| | DSE 4 (c) | Queueing Theory | E | 4 | 3 | 2 | 5 |
| | GE 4 (a) | To opt from sister departments | E | 4 | 3 | 2 | 5 |
| | GE 4 (b) | Statistics – II (To offer to sister Departments) | E | 4 | 3 | 2 | 5 |

Abbreviation used : L = Lecture , T = Tutorial, P = Practical, CH = Class Hour (per week),

C = Core, DSE = Discipline Specific Elective, GE = Generic Elective,

Cij = jth core paper in the i-th semester, i, j = 1, 2, 3, 4

**Note :** In case of DSE a student can opt for only one course in each semester from different alternatives.

# Details Syllabus of the M.Sc. Programme in Statistics under Choice Based Credit System

**Course No. :** C11 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Applied Probability Theory

Classes of sets; Algebra of sets; Sequence and Limits of sets; field, $\sigma$-fields and Borel fields; Partition ; Monotone fields; Class of events; set functions and properties; Idea of measure, probability measure and properties, properties of measure ; Lebesgue measure ; Lebesgue-Stieltjes measure; Lebesgue Integral, L-S Integral, Measureable functions; Random variables. (15L)

Combinatorics: pigeon-hole principle, inclusion-exclusion principle, Cartesian product-Fundamental theorem of Cartesian product, Multinomial and hypergeometric formulae and occupancy vector and applications. (5L)

Computation of probability, expectation, variance by conditioning and applications; computation of expectation, variance of compound random variables; Generating function : probability generating function ( univariate and multivariate ), properties, theorems and applications; characteristic function ( univariate and multivariate ), properties, inversion theorem, continuity theorem and applications ( Emphasis would be given on compound random variables and their applications) (10L)

Inequalities : Markov, Tschebyshev and Bienym inequality and Chernoff's bounds with application; Modes of convergence: convergence in probability and distributions; Limit theorems : Weak and strong laws of large numbers - Bernoulli, Tschebyshev , Khintchine, Borel and Kolmogorov laws of large numbers with applications ; Central limit theorem (CLT)- DeMoivre-Laplace; Levy-Lindeberg, and Liapounoff's CLT , Cramer's theorem, applications and essence. (15L)

**(45L + 15T)**

**References:**


1. Medhi, J : Stochastic Processes, third edition, New Age International (p) Ltd. publishers
2. Feller, W.: An Introduction to Probability and its Applications, Wiley
3. Hogg R.V. and Craig A.T.: Introduction to Mathematical Statistic, McMillan.
4. Pitman, J.: Probability, Narosa Pub. House.
5. David. S, : Elementary Probability , Cambridge University Press.
6. Ash Robert: Real Analysis and Probability, Academic Press
7. Kingman, JFC and Taylor, S.J: Introduction to Measure and Probability, Cambridge University Press.
8. Bhat B.R.: Modern Probability Theory: An Introductory Text Book, New Age International (P) Limited.
9. Chung K.L. : A Course in Probability Theory Harcourt Brace, New York.
10. Gnedenko B.V. : The Theory of Probability, Mir Publishers, Moscow.
11. Ross, S.M : Introduction to probability models , Wiley publication
12. Halmos P.R.: Measure Theory Von-Nostrand, Princeton.
13. Adke, S.R. and Manjunath S.M. : An Introduction to Finite Markov Processes, Wiley Eastern
14. Bartholomew, D.J. : Stochastic Models for Social Processes, Wiley, second edition
15. Ross, S.M. : Stochastic Processes, Wiley


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** C12 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Mathematical Analysis and Linear Algebra

Basic concepts of real analysis: Sequence, series, real valued functions.
Uniform continuity and uniform convergence. Convergence of series.
Riemann Integral. Improper Integral. Convergence of Improper integrals-its significance in statistics.
Integral transform: Laplace transform(LT). LT of elementary functions, derivatives. Inverse LT. Uniqueness, continuity and convolution theorem of LT. Its application in solving differential equation, determining distribution in statistics. (10L)
Algebra of complex numbers. Analytic functions. Cauchy's theorem and Cauchy's integral formulae. Power series – Residue theorem and contour integration. (10L)
Field, vector space, basis, dimensions, Linear dependence and independence pf vectors. Orthogonal and orthonormal vectors. Gram-Schmidt process with example. (5L)
Homogeneous and non-homogeneous linear equations. Generalised inverse-its computation and applications. Moore-Penrose generalized inverse–its uniqueness Property. (6L)

Characteristic vectors and roots of matrices – properties in details. Cayley Hamilton theorem, its uses of powering and inverting square matrices. Diagonalization of matrices and its applications. Spectral decomposition of symmetric and asymmetric matrices - its uses. Real Quadratic form(QF): Definition and classification. Reduction of Q.F.. Cochran's theorem – its application in statistical analysis. (14L)

**(45L + 10T + 5P)**

**References:**


1. Bellman, R.: Introduction to matrix Algebra, McGraw Hill
2. Biswas,S.: Topic in algebra of Matrices, Academic Press.
3. Chaturvedi : Real Analysis
4. Narayan, S. : (a) Real analysis (b) Complex analysis, S.Chand and Co.
5. Rao,C.R. and Mitra, S.K.: Generalised Inverse of matrices and its applications, J.W.
6. Spiegel, M.R.: (a) Laplace transforms (b)Matrices (c) Complex Variable Schaum's outline series.
7. Mukhopadhyay, P.: Mathematical Statistics Central , New Book Agency (P) Ltd.
8. Lay, David : Linear Algebra and its applications, Pearson Education
9. Graybill, F.A. : Introduction to matrices with application in Statistics
10. Kasana, H.S. : Complex Variable – theory and applications, Prentice Hall of India.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** C13 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Statistics with Computer

**Programming with *C*:**

Definition of High-Level and Low-Level Programming Language. Short History of *C* and its evolution. Algorithm and Flowchart. General structure of a computer program. Constants, variables and declarations. Library functions. Simple input-output statement. Operators- arithmetic, logical, conditional, relational, increment, decrement. Looping Structure- for, while, do-while. Conditional statements- if, else, goto, nesting of if-statements. Data type- integer, real, character, long etc. Arrays of fixed length and storing of values. Pointer and its use to create dynamic memory allocation. User defined functions. Application to simple mathematical and logical problems.

(10L + 2P)

Creating frequency distribution from raw data. Sorting- Selection, bubble. Computation of popular summary statistics- mean, median, mode, quantiles, moments, correlation. Fitting of basic distributions. Interpolation using Lagrange's formula. Numerical solution of equation- Iterative, Newton-Raphson. Generating random numbers by linear congruence method and goodness of fit test. Generating random observations from standard discrete distributions- binomial, Poisson, geometric, negative binomial, hypergeometric. Generating random observations from standard discrete and continuous distributions. (10L + 4P)

**Programming and Analytics with *R:***

Going from *C* to *R*- Similarities and dissimilarities. *R-GUI* and *R-Studio*. Advantages of *R*. Data types in *R*. *R*-Graphics. Basic statistics using *R*. Installing packages from CRAN-mirror and using available functions. Using Help page. Reading data from files and writing output in files. ( 5L + 2P )

Linear algebra using *R*- Matrix operations, finding rank, finding a basis, inverse and G-inverse, LU,QR and SV decomposition, condition number. Linear Models using *R* – Simple Regression, ANOVA, ANCOVA using lm( ) function. ( 10L + 3P)

Random observation generation from various univariate and multivariate distributions using available functions. Simulation- Definition and fields of application. Calculating area of irregular geometric structures and related graphics. Calculating probability of events by empirical definition of probability. Verification of important asymptotic results. Determining size of a test. Drawing power curve of some tests. Evaluating performance of an estimator. Construction of confidence ellipsoids. (10L + 4P)

**(45L + 15P)**

**References:**

1. P. Dalgaard : Introductory Statistics with R, Springer, 2nded, 2008.
2. Madhumangal Pal: *C* Programming: Including Numerical and Statistical Methods, 2012, alpha science.

3. J. Maindonald & J. Braun : Data Analysis and Graphics Using R , Cambridge University Press, Cambridge, 2nd edition, 2007.
4. Hadley Wickham: R Packages: Organize, Test, Document and Share Your Code,2015.
5. Frank Bretz, Torsten Hothorn, Peter H. Westfall: Multiple Comparisons using R, CRC Press.
6. D.E.Knuth : The Art of Computer Programming (Vol. 1 &2).

Total Lectures of 1 hour duration : 45
Total Practical classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** DSE 1 (a) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Industrial Statistics

**Operations Research:**

History of Operations Research. (3L)

Introduction. Linear Programming: Mathematical formulation of Linear Programming. Application of Linear Progr4amming,Limitations Geometric solution of LPP, vector spaces, Basis, linear transformations, Convex sets, extreme points and Convey polyhedral sets, simplex algorithm – its theory and computational details. Solution of LP by Simplex techniques in presence of slack, or/and surplus or/and artificial variables; Degeneracy in LPP. Resolution of degeneracy, Duality in LPP. Assignment problem (Balance and Unbalance), Unbalance assignment problem, Applications. Sequencing problems and related sums. Transportation Problem and application.

(20L)

**Statistical Quality Control :**

Quality Movements, The Magnificent seven tools of SPC and its implementation
A brief idea on Quality in education and health care industry (8L)
Double sampling & Sequential Sampling plan by Attributes. Un-Known sigma sampling by variables (5L)
Cumulative Sum (CUSUM) control charts( Tabular CUSUM), concepts of Average Run Length(ARL) (5L)
A brief idea on inspection error in SQC .
Taguchi's definition of quality & loss functions.
Concepts of Total quality control (TQC) & Total Quality Management (TQM) (4L)

**(45L + 15T)**

**References :**


1. Churchman, C.W, R.L. and E.L. Arnoff. (1957), "Introduction to Operations Research" John Wiley and sons, New York.
2. Gupta K.P.K and Mohan M. (1994) "Operations Research", S.Chand and sons, New Delhi.
3. Sarma S.D. "Operations Research".
4. Wagner, H.M. (1973), "Principles of OR with Applications to Managerial Decisions," Prentice Hall.
5. Tata, H.A. (1982), "Operational Research": An Introduction", Macmillan.
6. Philips D.T., A. Ravindran and J.Solberg. "Operations Research: Principles and Practice",
7. Duncan, A.J. (1967): Quality control & Industrial Statistics: (Indian edition) D.B. Taraporevella & Sons Co. Pvt. Ltd., Bombay.
8. Montgomery, D.C. (1996): Introduction to Statistical Quality Control, John Wiley & Sons, N.Y.
9. Taguchi, G. (1986) :Introduction to Quality Engineering: Design quality in to Products: Asian productivity organizations, Tokoya.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** DSE 1 (b) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Demography

Demographic Data : Sources of demographic data their nature and limitations. Demographic scenario of India according to the latest census.
Data appraisal : methods of evaluation and adjustment of data. (3L)

Fertility : different rates, their computations and sources of data. Standardization of fertility rates. Indirect methods of estimating fertility. (6L)
Mortality and Morbidity : Different rates of mortality. Standardization of mortality rates. Adjustment of IMR. Indirect methods of mortality estimation. Concepts and definitions, different measures of morbidity.
(8L)
Life Table - Basic concepts; types and forms. Construction of abridged life tables. Interrelations of life table functions. Sampling distributions of life table functions $l_x$ and $d_x$.
(7L)
Population Projection and Estimation: Inter-censal and post-censal estimates. Population projection- models for population growth curves. Fitting of log-growth curves and its properties. (8L)

Concept of stable, quasi-stable and stationary population. Lotka's fundamental equation. Component method of population projection – its representation with the Leslie matrix. Properties of Leslie matrix (time independent). (7L)

Idea of stochastic models on fertility and reproduction – William Brass Model and Sheps and Perrin model.
Migration: Basic concepts, internal and international migration – causes and consequences, its estimation. (6L)

**(45L + 10T + 5P)**

**References:**


1. Bhende, A.A. and Kanitkar T. : Principles of Population studies , Himalays Publishing House
2. Biswas, S.: Stochastic Processes in demography and applications, Wiley Eastern Ltd
3. Mukhopadhyay, P. : Applied Statistics, Central Book Agency.
4. Pathak, K. B. Pandey, A. : Stochastic models for human reproduction, Himalaya Pub-House
5. Pathak, K.B. and Ram, F: Techniques of Demographic analysis, Himalaya Pub. House.
6. Ramkumar, R.: Technical Demography Wiley Eastern.
7. Pathak, K.B. and Pandey, A. : Stochastic models on Human Reproduction, Himalaya Publishing House.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** DSE 1 (c) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Operations Research

Game Theory : Characteristics of Game Theory.
The mini-max (maxi-min) principles, Fundamental theorems. Methods for solving game problems with and without saddle point(s). Equivalence of games and Linear programming problems. (11L)

Project management, PERT/CPM techniques, Applications, Time estimates and critical path in Network analysis. Updating, Network crashing, Ideas of Resource allocation.
( 8L)

Simulation : Generation of pseudo- random number, Linear congenital generator; generation of random variates from specified distribution – inverse transform method, Acceptance – rejection method, improved – rejection method; Generation of normal variates – Box-Muller algorithm, Approximate methods; generation of a series of sets of normal variates – Matrix method.
(10L)

Introduction to Dynamic Programming- shortest-path problem, optimal subdivision, maintenance problem. Integer programming and applications. (16L)

**(45L + 10T + 5P)**

**References :**


1. Sharma S.D. 'Operations Research'
2. Swarup K., Gupta P.K. and Mohan M. (1994), 'Operations Research', S.Chand and Sons, New Delhi.
3. Churchman C.W., Ackoff R.L. and Arnoff E.L., (1957), 'Introduction to Operations Research' John Wiley.
4. Hadley G. (1964) 'Non-Linear and Dynamic programming', Addison Wesley.
5. Wagner H.M. (1973). 'Principles OR with applications to Managerial decisions' Prentice Hall,
6. Taha H.A. (1982) 'Operational Research: An introduction', Macmillan.
7. Hillier F-S and . Leiberman G.J 'Introduction to Operations Research', Holden Day.
8. Murthy K.G. 'Linear programming', John Wiley
9. . Bazarra M.S, Jarvis J.J. & Sherali H.D. 'Linear programming and Network Flows', John Wiley & sons.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** AEC I Marks : 50 (In-sem : 20 + End Sem. : 30)

**Title of the Course :** Analysis I

Sequence and series, convergence, limsup, liminf; (3L)

Monotonic functions, functions of bounded variation, Continuity, uniform continuity, types of discontinuity, differentiability, mean value theorem; (6L)

Sequences and series of functions, uniform convergence; (4L)

Functions of several variables, continuity, directional derivatives, partial derivatives, total derivatives, maxima and minima, saddle point, method of Lagrange's multipliers; Double and Triple integrals and their applications; Line integrals and Surface integrals (9L)

**(22L + 8T)**

**References :**

1. Apostol T.M. (1974), Mathematical Analysis'($2^{nd}$ edition), Addison-Wesley Publishing Company, Reading, Mass
2. Apostol T.M. (1967), 'Calculus', Vol. 1 ($2^{nd}$ edition), Zerox Waltham
3. Gibson G.A. (1958), 'Advanced Calculus', Macmillan and Company Ltd., London and St. Martin's Press, New York
4. Halmos P.R. (1950), 'Measure Theory', Van Nostrand, Princeton, N.J. (reprinted in India, East West Press).
5. Kolmogorov A.N. and Fomin S.V. (1970)., 'Introductory Real Analysis' (revised English edition by Richard A Silverman), Prentice-Hall Inc. Englewood Cliffs, New Jersey.

Total Lectures of 1 hour duration : 22
Total Tutorial classes of 1 hour duration : 08
Total Credits after calculation : 2 credits

**Course No. :** C21 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Probability Distribution and Reliability

Multidimensional Random Variable : - Distribution function and its properties; joint distribution; Marginal distribution; Conditional distribution; Independence; Derivation of distribution of function of several random variables using methods of distribution functions, Method of transformations, Method based on moment generating function or characteristic functions; Covariance, Correlation and moments; Conditional expectations. Distributions of order statistics and their applications. (12L)

Truncated, Mixture and stopped-sum distributions. (3L)

Bivariate Bionomial and Poisson distributions. (5L)

Sampling Distributions : non central $\chi^2, t, F$ (5L)

Skew distributions and its properties; Beta generated family of distributions; weighted distributions. (8L)

**Reliability**

Concepts and definitions of reliability: Time-To-Failure, Reliability function, MTTF, failure rate, Cumulative failure rate, their relations, bath-tub-curve. Mean time to failure (MTTF), Conditional reliability, Mean residual life time. Constant and time dependent Failure models. System Reliability: Series, Parallel system and k-out-of-n systems. Component and system level redundancies. (12L)

**(45L + 15T)**

**References:**


1. Rohatgi V.K., Saleh A.K.Md., An Introduction to Probability and Statistics- Wiley.
2. Mood A. M., Graybill F. A., Boes D. C. Introduction to theory of Statistics-, Tata McGraw Hill.
3. Jhonson N. L., Kotz S., Kemp A. W., Discrete Distribution - John Wiley.
4. Johnson N. L., Kotz S., Balakrishnan N. Continuous Distribution- Vol.1 and Vol.2 -; John Wiley.
5. Johnson N. L., Kotz S., Balakrishnan N. Discrete Multivariate Distributions, John Wiley
6. Kochrlakota S. and Kochrlakota K., Bivariate Discrete Distributions, Marcel Dekker.
7. Mukherjee P. Mathematical Statistics, Central.
8. Ross S. M., Simulation, Academic Press
9. Rubinstein R.Y., Simulation and Monte Carlo Methods
10. Dudewicz E. J. and Misra S. N., Modern Mathematical Statistics.
11. Ross S. M., An introduction to probability models, Academic Press.
12. Trivedi K. S. Probability & Statistics with Reliability, Queuing & Computer Science Applications, PHI.
13. Ebeling C. E., An introduction to Reliability and Maintainability Engineering- Tata McGraw-Hill
14. Hoyland A., Rausand M System Reliability theory-models and applications, John Wiley.

15. Balagurswamy, E.(1984) : Reliability Engineering, Tata McGraw Hill Publishing Co., New Delhi.
16. Barlow, R.E. and Pischan , F (1965): Mathematical Theory of reliability, John Wiley and Sons, New York.
17. Polvoko, A.M. (1968): Fundamentals of Reliability Theory, Academic Press, New York.
18. Medhi, J. : Stochastic Process, Wiley Eastern.
19. Kapur, K.C. and lamberson, L.R.(1977): Reliability Engineering, John wiley and Sons, New York.

| | |
|---|---|
| Total Lectures of 1 hour duration | : 45 |
| Total Tutorial classes of 1 hour duration | : 15 |
| Total Credits after calculation | : 4 credits |

**Course No. :** C22 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Estimation Theory

Theory of Point Estimation : Fisher's & other criteria of a good estimator. (7L)
Concept of exponential family of distributions; sufficiency : Factorization theorem of sufficiency, distribution possessing sufficient Statistics, Complete and minimal sufficient Statistics. (8L)

Cramer Rao Inequality and its modifications : Fisher information for one and several parameter models; Uniformly Minimum Variance Unbiased Estimator (UMVUE), NASC for the existence of UMVUE; Rao-Blackwell theorem, Lehman Scheffe's theorem. (8L)

Methods of Estimation: Maximum Likelihood Method – its properties; Methods of Moments and minimum $\chi^2$. (10L)

Interval Estimation: Basic concepts; Methods of obtaining confidence Intervals; Shortest and Expected shortest confidence interval. (8L)

Bayesian estimation: Prior, Posterior, Loss functions, estimation using different loss functions, Credible interval. (4L)

**(45L + 15T)**

**References:**


1. Mukhopadhyay, Parimal (2000): Mathematical Statistics, 2nd Ed. , Books and Allied (P) Ltd., Kolkata-700009
2. Rohatgi, V. & M.E. Salch (1993): An Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
3. Kale, B.K. (1999) : A First Course on Parametric Inference, Narosa Publishing House, New Delhi.]
4. Berger, J.O. (1985): Statistical Decision Theory and Baysian Analysis. Springer-Verleg, Holland
5. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern (P) Ltd., New Delhi
6. Zacks, S.(1971) : Theory of Statistical Inference, John Wiley and Sons, New York.
7. Leonard, T and Hsu, J.S.J.: Bayesian Methods, Cambridge University Press, London.
8. Mood, Graybill & Boes : Statistical Inference
9. Christian P. Robert : The Bayesian Choice, 2nd Edition, Springer


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** C23 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Regression Analysis

Multivariate regression models; Estimation of model parameters. Hypothesis testing in multiple linear regressions, Regression with and without intercept. Standardized regression coefficients and interpretations; $R^2$ and Adjusted $R^2$. (12L)

Residual analysis – Definition; Residual Plots, Normal probability plots; Methods of scaling residuals-standardized and studentized residual (emphasis to be given on case studies/examples). Lack of fit test in regression model. (5L)

Variable selection and Model Building; Model building problem, Model misspecification criteria for evaluating sub set regressions. (6L)

Computational technique for variable selection- All possible regressions, stepwise regression , $R^2$ Adjusted $R^2$, MSE and Mellow's $C_p$, statistic (without derivation). ( 6L)

Regression on dummy Variables – Dummy as explanatory variable. Chow test vs Dummy variable Approach. (8L)

Generalized linear models – LPM, Logistic regression for dichotomous data with single and multiple explanatory variables estimation, goodness of fit. (8L)

**(45L + 10T + 5P)**

**References:**


1. Montgomery D.C. Peck, E.A., Vinning G.G. : Introduction to Linear Regression Analysis, Wiley series in Probability and Statistics.
2. NetorJ, Wasserman, W.: Applied Linear Statistical Model, Richard D.Irwin Inc.]
3. Drpper N.R.,Smith H : Applied Regression Analysis Wiley Series in Probability and Stats.
4. Mukhopadhyay, P.: Mathematical Statistics Central , New Book Agency (P) Ltd.
5. Chatterjee S. price B: Regression Analysis by Example John Wiley


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** DSE 2 (a) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Quantitative Epidemiology & Biostatistics

**Quantitative Epidemiology :**

Introduction to modern epidemiology, principles of epidemiological investigations. Sources of Epidemiologic data. Risk factors, odds ratio, relative risk. Measures of diseases frequency, measures of effect and association. (6L)

Types of studies – prospective, retrospective, cross-sectional studies. Inference for relative risk and odds ratio. Inference for ratios from s-independent 2X2 tables (8L)

Regression models for the estimation of relative risk, odd ratio, meta-analysis. Mantel-Haenszel procedure and weighted least squares procedure in the analysis of epidemiological data. Quantitative methods in screening. (8L)

**Biostatistics :**

Basic concepts of Biostatistics and its scope. Idea of Bioassay. Clinical trial-meaning, scope, ethics and phases. Determination of sample size in biostatistical problem. (7L)

Survival Analysis : concepts of time, order, censoring, truncation, competing risk. survival function, hazard function. (5L)

Estimation of survival function. Parametric methods. Non–parametric methods – actuarial and Kaplan-Meier method, application (5L)

Mantel-Haenszel test, log rank test. Cox proportional hazard model and its applications. (6L)

**(45L + 10T + 5P)**

**References:**


1. Rothman K.J. Greenland S : Modern Epidemiology Lippin cott-Raven
2. Selvin S.: Statistical Analysis of Epidemiological D ata, Oxford University Press.
3. Jekel,J.F, Katz,D.L. Elmore, J.G. : Epidemiology, Bio-statistics and Prentice Medicine.
4. Chiang,C.L. : Introduction to stochastic processes in Bio-statistics, John Wiley
5. Cox, D.R. and Oakes, D.: Analysis of Survival data, Chapman Hall, N.Y.
6. Friedman, L.M.,Furburg, C, Demets, D.L. : Fundamental of Clinical Trials, Springer Verlag.
7. Miller, R.G. : Survival Analysis
8. Finney, D.J. : Statistical methods in biological assays. Charles Griffin and Co.
9. S.Biswas: Applied Stochastic Processes, A Bio-statistical and Population Oriented Approach, New Age International Ltd.
10. Indrayan, A. and Sarmukaddam, S.B. : Medical Biostatistics, Taylor and Francis.
11. Rao, P.S.S.S. and Richard J. : Introduction to Biostatistics and Research Methods, Prentice Hall of India, 4th edition.
12. Klein, J.P. and Moeshberger, M.L. : Survival Analysis – Techniques for Censored and Truncated Data, Springer, 2nd edition.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** DSE 2 (b) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Official Statistics

Introduction to Indian and International Statistical systems. Role, function and activities of Central and State statistical organizations. Organization of large-scale sample surveys. Role of National Sample Survey Organization. General and special data dissemination systems. (12L)

Population growth in developed and developing countries, evaluation of performance of family welfare programs, projections of labour force and manpower. Scope and content of population census of India (12L)

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics (8L)

Economic development: Growth in per capita income and distributive justice indices of development, Human development Index. (3L)

National Income Estimation Product approach, income approach and expenditure approach. Measuring inequality in incomes: Gini Coefficient, Theil's measure. (5L)

Poverty measurements: different issues, measures of incidence and intensity, combined measures: indices due to Kakwani and Sen.

National Statistical Commission: its role and functions. (5L)

**(45L + 15T)**

**References:**


1. Basic Statistics Relating to the Indian Economy (CSO) 1990
2. Guide to Official Statistics (CSO) 1999
3. Statistical System in India (CSO) 1995.
4. Principles and accommodation of National Population Censuses, UNEDCO.
5. Panse, V.G. Estimation of Crop Yields (FAO)
6. Family welfare Yearbook. Annual Publication of D/O Family Welfare
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publication.
8. C S O (1989) a: National Accounts statistics- Sources& Methods
9. Keyfitz,N.(1977): Applied Mathematical demography- Springer Verlag.
10. Sen, A (1977)- Poverty & Inequality
11. UNESCO: Principles for vital statistics systems, series M-12
12. CSO (1989)b: Statistical system in India
13. Chaubey P.K. 91995) : Poverty Measurement, New Age.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** DSE 2 (c) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Financial Statistics

What financial statistics is, why financial statistics is; Essentials/ Components of financial statistics; Role and functions of RBI, Economics Survey Department, CSO, Govt. of India; National Income Statistics, Modeling of National Income – Pareto's Law; Weibul distribution, Appropriate Pearsonian Curve, Idea of Stock Exchange, Statistics related to stock exchange, Time- Series modeling of stock exchange outcome. (10L)

Indicators of Economics Growth : Brief Resume of Indicators – Gross Domestic Product (GDP),Balance of payment, Foreign exchange reservoir, Foreign Exchange Earnings, Trade Balance, Exchange rates of Indian rupee, Govt's Receipts (tax and non-tax revenue ) and Govt. Expenditure, Gross Domestic Saving, Gross Domestic Capital Formation, Foreign Capital Inflow / Outflow. (13L)

Export Input Potential – Statistical Analysis of Export of Major Products and services of India. Industrial and Engineering Product, Time Series Modeling of Export Import Scenario of Indian Economy. (9L)

Growth and Stagnancy Analysis of Major Products and services of India ( mentioned in above paragraph ) Time Series / Regression modeling of Growth of Indian products – Logistic, Gompertz, Exponential, Reciprocal curves and Logarithmic curves and Validation of the Modeling . (13L)

**(45L + 15T)**

**References :**


1. Basic Statistics related of Indian Economy ( Yearly publication )
2. EMI Volumes ( Yearly publications )
3. CSO Publication ( Yearly publications )
4. Productivity News : National Productivity Council, A bi-monthly magazine
5. Southern Economist : Asian New Age Publisher, A monthly magazine
6. Economic and Political Weekly : A Sameeksha Publication
7. Monthly Commentary on Indian Economic Conditions : Indian Institute of Public Opinion, A - monthly journal
8. Indian Journal of Economics : Published by Dept. of Economics & Commerce, University of Allahabad
9. The Economic Times : A daily published National Daily
10. D. Ruppert : Statistics and Finance An Introductions, Cornell Univ. USA, SPRINGER
11. J.M. Steele : Stochastic Calculus, University of Pensylvania, USA, SPRINGER
12. Peta Rossi : Quantitative Marketing and Economics, SPRINGER
13. Hebden, J.( 1986), Statistics for Economists, Heritage Publisher, New Delhi


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. : GE 2** Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course : Statistics I**

Definition of Statistics, statistical data: qualitative and quantitative, discrete and continuous data, univariate and multivariate, primary and secondary, time series data, cross-sectional data, censored data. Scales of measurement. Summarization of data: univariate frequency distribution, outliers and extremes, graphical presentation with histogram, frequency curve and ogive, summary measures - mean, median, mode, standard deviation, moments, coefficient of variation, skewness and kurtosis.

(13L)

Bivariate frequency distribution: scatter diagram. Linear correlation and regression in bivariate setup. Correlation and causation. Idea of multiple linear regressions. Correlation of ranked data. (8L)

Probability. Conditional probability and Baye's theorem. Random variables- discrete and continuous, expectation and variance of random variables. Generating functions- MGF, PGF Characteristic Function and their applications. Probability models- binomial, Poisson, exponential and normal. Probability inequalities. Law of large numbers, Central Limit Theorem and their applications.

(16L)

Statistical inference. Parameter and statistic, statistical hypothesis, null and alternative hypothesis, type- I and type-II error, level of significance, p-value, one-tailed and two-tailed test. Different steps in a hypothesis testing problem. t-test, z-test, $\chi^2$ test and their applications. Idea of non-parametric methods.

(8L)

**(45L + 15T)**

**References :**


1. Bhatt. B. R : Modern Probability Theory, New Age International.
2. Croxton. F. E, Cowden D. J, Klein, Applied General Statistics, Prentice Hall of Indian Private dimited.
3. Medhi, J, Statistical Methods.
4. Spiegal, H. R Stephens L. J : Theory and problems of statistics.
5. Tata Mc Graw Hill.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** C31 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Testing of Hypotheses

Concept of hypothesis, Statistical hypothesis, critical region, test function, two kinds of error, power function, level of significance; MP test, UMP test and UMPU test. (4L)

Randomized tests : Neyman Pearson lemma; illustration through examples on binomial and Poisson. (4L)

Nonrandomized tests : Construction of MPCR, UMPCR, type A, type $A_1$ critical regions (using Neyman Pearson lemma); concept of monotone likelihood ratio. (11L)

Similar regions : Construction of MP similar regions (Neyman structure). (8L)

Likelihood Ratio Test : its properties and examples (7L)

Sequential Analysis : Notions of sequential analysis, Wald's SPRT- its properties and applications, OC function, ASN function, Wald's fundamental identity. (11L)

**(45L + 10T + 5P)**

**References:**


1. Mukhopadhyay, Parimal (2000): Mathematical Statistics ($2^{nd}$ Ed.). Books and Allied (P) Ltd., Kolkata-700009.
2. Rohatgi: V.K. and Saleh, M.E. ( ) : An Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
3. Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House, New Delhi.
4. Rao, C.Radhakrishna (1973): Linear Statistical Inference and Its Applications, Wiley Eastern (P) Ltd., New Delhi.
5. Lehman, E.L. (1986): Testing of statistical Hypotheses, John Wiley and Sons, New York.
6. Wald, A (1947): Sequential Analysis, John Wiley, New York.
7. Ghosh, B.K. : Sequential Analysis


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** C32 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Non-parametric Inference

Concept of nonparametric tests, advantages and disadvantages of nonparametric tests, areas of applications. Order Statistics and its uses in non-parametric inference. (4L)

Nonparametric tests for goodness of fit – Kolmogrov Smirnov test, Anderson-Darling test, comparisons with chi-squares test, One sample problem- Sign test, Wilcoxon sign rank test, applications. (6L)

Kolmogrov Smirnov two sample problem, Wilcoxon Rank Sum test, Mann Whitney test, Median test, Run test. (6L)

Definition of linear rank Statistics, Distribution properties of linear rank Statistics, Usefulness in Inference problem, Linear Rank tests for location problem, Wilcoxon test, Terry-Hoeffding test, Vander Warden Test. (8L)

Multi sample location tests : Median test, Kruskal – Wallis test, normal score test, Friedman test for block designs. (6L)

Linear rank test for scale problem, Mood test, Ansari – Breadley – Freund – Barton – David test, Siegal – Tukey test, Klotz normal score test, Sukhatme test. (5L )

Nonparametric test for ordered alternatives – Jonckeere test, page test (5L)

Concepts of Asymptotic relatives efficiency ( ARE ), ARE of Mann – Whitney test over Student t-test, ARE of Kruskal Wallis test over F – test (5L)

**(45L + 10T + 5P)**

**References :**


1. Gibbons, J.D. : Nonparametric Statistical Inference , McGraw Hill Book Academy
2. Hettmansperger, T.P. : Statistical Inference based on Ranks, Wiley
3. Hajek, J. and Sidak, Z. Theory of Ranks, Academic Press
4. Randles, R.H. and Wolfe, D.A. : Introduction to the Theory of Nonparametric Statistics, Wiley
5. Sethuraman, J. : Nonparametric Technique in Statistical Inference, Cambridge University Press
6. Krishnaiah, P.R. and Sen, P.K. : Nonparametric methods in directional data analysis
7. Mooney, C..Z. and Duval , R.D. : Bootstrapping : A nonparametric approach to Statistical Inference, SAGE publication
8. Govindrajulu, Z. : Nonparametric Inference
9. Desu, M.M. and Raghavarao, D. : Nonparametric Statistical Methods
10. Peter Sprent : Applied Nonparametric Statistical Methods
11. Bradley, J.V. : Distribution – free tests, Prentice Hall
12. Lehmann, E.L.: Nonparametric Tests Based on Ranks, San Francies Co. Holden Day, Ins.
13. Conver, W.J. : Practical Nonparametric Statistics, John Wiley and Sons, New York


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** C33 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Stochastic Processes

Introduction to stochastic process; Markov chains (MC), higher order transition probabilities – Chapman-Kolmogorov theorem, Spectral decomposition; classification of states : transient and recurrent and associated theorem(s); canonical form; Periodicity of Markov Chain; classification of Markov Chain – irreducible and reducible chain, limiting and stationary distribution of Markov Chain; applications of Markov Chain in social, physical and behavioural sciences, Absorbing and Non absorbing Markov Chain and their real life application. Martingales : Definition, classification, properties and applications; Martingales in Random walk, gambler's ruin problem.

(16L)

Markov Process with discrete state space : Poisson process ( time homogenous and non homogenous ), properties and applications; Chapman – Kolmogorov differential equations (backward and forward ), HSD and HSTD model, pure birth process, birth – immigration process, birth and death process ( M/M/S ), linear growth model with immigration, two sex population growth model, immigration –emigration (M/M/I ) process .

(13L)

Renewal process in discrete time, Renewal Interval, Renewal process in continuous time, Renewal function and Renewal Density, Markov renewal and Semi-Markov Processes, Waiting times, Markov renewal equation, Interval transition probability matrix, Limiting behavior, Limiting distribution of Semi-Markov Process and recurrence times, First passage time.

(16L)

**(45L + 12T + 3P)**

**References:**


1. Medhi, J : Stochastic Processes, third edition, New Age International (p) Ltd. publishers
2. Bhat, U.N. : Stochastic Models, New Age Int., India
3. Adke, S.R. and Manjunath, S.M. : An Introduction to finite Markov Processes, Wiley Eastern.
4. Parzen, E. : Stochastic Processes, Holden-Day.
5. Feller, W.: An Introduction to Probability and its Applications, Wiley
6. Chung, K.L. : A Course in Probability Theory Harcourt Brace, New York.
7. Gnedenko, B.V. : The Theory of Probability, Mir Publishers, Moscow.
8. Ross, S.M : Introduction to probability models , Wiley publication
9. Bartholomew, D.J. : Stochastic Models for Social Processes, Wiley, second edition
10. Ross, S.M. : Stochastic Processes, Wiley


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 12
Total practical classes of 1 hour duration : 3
Total Credits after calculation : 4 credits

**Course No. :** DSE 3 (a) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Econometrics

The Classical Linear Normal Regression Model (CLNRM) (Matrix Approach): Estimation, Test and their properties. (6L)
Heterosedaticity: consequences, detection and Remedies. (6L)
Autocorrelation: consequences, detection and Remedies. (6L)
Multicollinearity: implications and tools for handling the problem. Ridge Regression (6L)
Generealised Least Squares (GLS) estimation: Heterosedaticity and autocorrelated structure. Zelner's SURE Method. (6L)

Simultaneous Linear Equations Model. Examples. Simultaneity bias. Identification problem-Rank and order conditions. Examples. (6L)

Estimation in simultaneous equations Model, ILS and 2 SLS Estimators, Full Information Maximum likelihood method. (6L)

Dynamic Econometric Models: Distributed lag Model and auto regressive model. (3L)

**(45L + 15T)**

**References:**


1. Gujarati,D.(1979): Basic Econometrics, McGraw Hill
2. Intrulligator,M.D.(1980): Econometric models- Techniques and applications, Prentice
3. Johnston, J.(1984):Econometric methods, Third edition, McGraw Hill
4. Klein,L.R.(1962): An Introduction to Econometrics, Prentice Hall of India
5. Apte P.G.(1990): Text book of Econometrics. Tata McGraw Hill
6. Cramer,J.S.(1971): Empirical Econometrics, North Holland
7. Gujarathi,D.(1979): Basic Econometrics, McGraw Hill
8. Intrulligator,M.D.(1980): Econometric models- Techniques and applications, Prentice
9. Koutsoyiannis, A.(1979) : Theory of Econometrics, Mcmillan Press.
10. Malinvaud, E.(1966): Statistical methods of Econometrics, North Holland.
11. Srivastava, V.K. and Giles D.A.E.(1987): Seemingly unrelated regression equations models, Maicel Dekker.
12. Theil,H.(1982): Introduction to the theory and practice of Econometrics, John wiley.
13. Walters, A (1970): An introduction to Econometrics, McMillan & Co.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. :** DSE 3 (b) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Reliability Engineering

IFR and DFR Distribution and their properties (without proof). Maintainability and Availability. Maintainability function, Availability function. Repairman problem, Two-unit parallel system with repair. System availability preventive maintenance. Replacement policies (11L)
Redundancy: Hot, cold and tepid. Imperfect switching. (8L)

Coherent systems, systems of independent components series, parellel and k-out-of n, and paths, bounds on system reliability. (8L)

Reliability evaluation in interference models: Evaluation of system reliability with Exponential and Normal stress-strength. Cascade system. Evaluation of Cascade redundancy for exponential and Normal distributions. (8L)

Life-testing and reliability estimation: Estimation of reliability for Exponential, Weibull and Normal distribution using complete and censored sample. (8L)

Idea of renewal theory (2L)

**(45L + 10T + 5P)**

**References:**


1. Balagursamy,E.(1984): Reliability Engineering, Tata McGraw Hill publishing Co.,New Delhi.
2. Barlow, R.E. and Proschan, F.(1965): Mathematical Theory of Reliability, John Wiley and sons, New york.
3. Barlow, R.E. and Proschan, F.( 1975): Statistical Theory of Reliability and Life Testing , John Wiley and Sons, New York.
4. Kapoor, K.C. and Lamberson, L.R.( 1977): Reliability Engineering, John wiley and Sons, new York.
5. Sinha, S.K. (1986): Reliability and Life Testing, Wiley Eastern, New York.
6. Gnedenko, B.V. Belyayav, Yu,K. and Solovyev, A.D. (1965): Mathematical Methods of Reliability Theory Academic Press, New York.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** AEC II Marks : 50 (In-sem : 20 + End Sem. : 30)

**Title of the Course :** Analysis II

Vector space, rank, and linear transformation; Jacobian of transformation; quadratic forms (QF) and definiteness and, related theorems. (6L)

Expectation and Covariance operators; Mean and Variance of Quadratic forms and related theorems. (5L)

Matrix differentiation and Extrema in QF and related theorems. Derivative of function w.r.t. vector , matrix , derivative of a matrix w.r.t. scalar. (6L)

Matrix application in evaluating multiple integrals and differentiation. Multivariate normal density, Moments of density function (multivariate) , expectation of random matrices. (5L)

**(22L + 8T)**

**References :**

1. Seber G.A.F. (1980): Linear Regression Analysis, Wiley Series in Mathematical Probabilities, 2nd edition
2. Rao R.A. and Bhimasankaran P. (2000) : Linear Algebra, Hindustan Book Agency, 2nd edition
3. Mardia K.V. , Kent J.T. and Bibby J.M. (1980) : Multivariate Analysis, Academic Press, 2nd print
4. Graybill : Introduction to Matrices with Application in Statistics, Wadsworth Publishing Company Inc.

Total Lectures of 1 hour duration : 22
Total Tutorial classes of 1 hour duration : 08
Total Credits after calculation : 2 credits

**Course No. :** C41 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Multivariate Methods

Multivariate normal distribution: Properties, Distribution of Linear and Quadratic forms. Estimation of mean vector and co-variance matrix. (8L)

Distribution of sample mean vector. Wishart distribution(without derivation) its properties. Hotelling $T^2$ statistic and its distribution in null case. Application of $T^2$ and its optimum properties. Distance function and Mahalonolis $D^2$ statistic. Distribution of multiple correlation co-efficient. Concept of Wilk's - $\lambda$ criterion. (14L)

Classification of observations: Problem, Preliminary consideration. Classification with Baye's rule. Linear and Quadratic discriminant analysis. Fisher's discriminant function. (12L)

Principal components: Definition, use, estimation and computation. Canonical correlation analysis: Introduction, Definition, estimation and computation. Factor analysis: Introduction, linear factor models, Estimation of factor loadings. Introduction to cluster analysis. (11L)

**(45L + 7T + 8P)**

**References:**


1. Anderson, T.W.(1983): An Introduction to Multivariate Statistical Analysis, Wiley Estern, New Delhi.
2. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, 3rd Edition, Prentice Hall
3. Khirsagar, A.M.(1972): Multivariate Analysis, Marcel-Dekker
4. Morrison, D.F.(1976): Multivariate Statistical Methods,2nd Ed. , McGraw Hill.
5. Mukhopadhyay, P.(1996): Mathematical Statistics, New Central Library Book Agency, Kolkata
6. Rao, C.R.(1973): Linear Statistical Inference and its Applications, 2nd Ed., Wiley Eastern, New Delhi.
7. Seber, G.A.F.(1984) : Multivariate observations, Wiley Eastern.
8. Sharma, S. (1996): Applied Multivariate Analysis, Wiley Eastern.
9. Srivastava, M.S. and Khatri,C.G.(1979): An Introduction to Multivariate Statistics, North-Holland Book Co.
10. K.Fukunaga (1990): Introduction to statistical pattern recognition, 2nd Ed. Academic Press.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 07
Total practical classes of 1 hour duration : 08
Total Credits after calculation : 4 credits

**Course No. :** C42 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Design and Analysis of Experiments

Linear Estimation:
Linear model fixed random effect model, model of full rank; multiple regression model, main effects model, interaction effects model. Gauss Markov set up, normal equations and Least Squares estimates, Error and estimation spaces, variance and covariances of least squares estimates, Estimation of error variance, estimation with correlated observations; Least squares estimators with restriction on parameters; simultaneous estimators of linear parametric functions. SS due to BLUE's Errors, Linear set and degrees of freedom; SS due to linear functions.
(11L)

Design of Experiment: Graeco Latin Square ,Quasi – Latin squares design, Factorial experiments: $2^n$ factorial experiment, Confounding in Factorial Experiments- $2^n$ (n = 3, 4, 5, 6 ) and $3^n$ (n = 2, 3) factorial Experiments. Double confounding in $2^n$ experiment. Fractional replication ( ½ , ¼ ) for $2^n$ experiment with confounding. Split Plot and Strip Plot Experiments.
(13L)

Connectedness and Orthogonality, Incomplete Block Designs. Balanced Incomplete Block Design (BIBD), Analysis with Intra block and Inter block information, Resolvable and affine Resolvable Designs. Partially Balanced Incomplete Block Design (PBIBD)- Analysis with two associate classes. (17L)

Response Surface Designs and analysis
. (4L)

**(45L + 10T + 5P)**

**References:**


1. Cochram, W.G. and Cox, G.M.(1992): Experimental Design Wiley Eastern Ltd., New Delhi.
2. Das, M.N. and Giri, N.C. (1994): Design and Analysis of Experiments, Wiley Eastern Ltd.
3. Goon, A.M.,Gupta, M.K. and Das Gupta, B.(1985), An Outline of Statistical Theory, Vol.2,TheWorld Press Ltd., Calcutta.
4. Joshi, D.D. (1987) : Linear Estimation and Design of Experiments, Wiley Eastern Ltd.
5. John, P.W.M. (1971): Statistical Design and Analysis of Experiment. McMillan
6. Kempthorne, O. (1965): Design and Analysis of Experiments, Wiley Eastern Ltd.
7. Montgomery , C.D. (1976): Design and Analysis of Experiments, Wiley , N.York.
8. Johnson, N.L. and Leon: Distributions and Experimental Design, Vol.2
9. Taguchi, G.(1986) :Introduction to Quality Engineering: Design quality in to Products: Asian productivity organizations, Tokoya.
10. Dey, Alok : Block Designs


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No. :** C43 Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Time Series Analysis

Time – series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. (6L)

Exploratory Time Series analysis: Test for trend and seasonality. Exponential and moving average smoothing. Holt and Winter's smoothing. Forecasting based on smoothing. (8L)

Correlogram Analysis with examples. Meaning of stationarity, Testing stationarity: graphical, DF and ADF tests. Detailed study of the stationary processes: (1) Moving Average (MA) (2) Auto Regressive (AR) (3) ARMA and (4) AR integrated MA (ARIMA) models. Box Jenkins Methodology. ARIMA (p,d,q) $(P,D,Q)^S$ . (20L)

Co-integration: its meaning and use. (3L)
Periodogram Analysis. (3L)

Multiple Time Series : Vector Autoregressive (VAR) Process – definition, stationarity, Estimation and Specification of a VAR processes, Forecasting VAR processes. (5L)

**(45L + 10T + 5P)**

**References :**


1. Box, G.E.P. and Jenkins, G.M. (1976): Time Series Analysis- Forecasting and Control, Holden-day, San Francisco.
2. Anderson, T.W. (1971): The Analysis of Time Series, Wiley, N.Y.
3. Montgemory, D.C. and Johnson, L.A.(1977): Forecasting and Time Series analysis, McGraw Hill.
4. Kendall,Sir Maurice and Ord., J.K.(1990):Time Series (Third Edition), Edward Arnold.
5. Brockwell, P.J. and Davis, R.A. Time Series: Theory and Methods (Second Edition), Springer-Verlag.
6. Fuller, W.A.(1976): Introduction of Statistical Time Series, John Wiley, N.Y.
7. Granger, C.W.J. and Newbold (1984): Forecasting Econometric Time Series, Third Ed., Academic Press.
8. Priestley, M.B.(1981): Spectral Analysis and Time Series, Griffin, London.
9. Kendall, M.G. and Stuart A.(1966): The advanced Theory of Statistics, Volume 3, Charles Griffin, London.
10. Bloomfield, P.(1976): Fourier Analysis of Time Series – An Introduction, Wiley.
11. Chatfield, Chris (1996) : The Analysis of Time Series : An Introduction, $6^{th}$ Edition, Chapman & Hall
12. Koopmans, L.H. (1974): The Spectral analysis of Time series, Academic Press.
13. Nelson, C.R.(1973): Applied Time Series for Managerial forecasting, Holden-Day
14. Findley, D.F.(Ed.) (1981): Applied Time Series analysis II, Academic press.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 10
Total practical classes of 1 hour duration : 5
Total Credits after calculation : 4 credits

**Course No.** **:** DSE 4 (a) Marks : 100 (Presentation & Viva-Voce : 40 + Dissertation. : 60)

**Title of the Course** **:** Dissertation

Guide line for the Project Work :

1. Project work shall be offered in the beginning of the 4th Semester
2. Project work shall be spread over the whole semester
3. Project work shall be consisting of following (and/or) components –

(a) Library works

(b) Field works/Theoretical works

4. Assessment shall be based on the dissertation, presentation and viva-voce. Viva-Voce test is open. But the candidate appearing the same examination will be allowed one by one.

A project shall be supervised by a faculty member assign by the DMC. There shall be an external examiner and an internal examiner (preferably the supervisor) for the evaluation of the project work. The project work should be chosen such that there is enough scope to apply and demonstrate the Statistical techniques learned in the theory course.

A dissertation shall clearly state the problem(s) addressed, objective(s), sampling design(in case of field work), the methodology adopted, the assumptions and hypotheses formulated, review literature consulted, Statistical analyses performed and the inferences drown.

Total Credits after calculation : 4 credits

**Course No. :** DSE 4 (b) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Bayesian Inference

Subjective interpretation of probability in terms of fair-odds- Evaluation of subjective probability of an event of an event using a subjectively unbiased coin-Subjective prior distribution of a parameter-Bayes theorem and computation of the posterior distribution. (5L)

Natural Conjugate family of priors for a model –Hyper parameter of a prior from conjugate family- Conjugate family for exponential family models-admitting sufficient statistics of fixed dimensions-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-Jerffrey's invariant priors, Maximum entropy priors. (12L)

Bayesian point estimation: Prediction problem from posterior distribution-Bayes estimates for absolute error loss, squared error loss and Linex loss and Entropy loss function - Generalization to convex loss functions-Evaluation of the estimate in terms of the posterior risk. (8L)

Bayesian interval estimation: Credible intervals-Highest posterior density regions-interpretation of the confidence coefficient of an interval. (6L)

Bayesian testing of hypothesis: Prior and posterior odds-Bayes factor for various types of testing hypothesis problem-Jeffery approach, Linley's paradox for testing a point hypothesis for normal mean. (6L)

Bayesian prediction problem: Standard Predictive distributions, Prediction for exponential family of distributions- predictive distributions and Reliability estimation-predictive interval-Ideas on Bayesian Robustness, Monte-Carlo Integration and Markov Chain Monte Carlo Technique(Without Proof). (8L)

**(45L + 15T)**

**References**


1. Bansal, A.K.(2007): Bayesian Parametric Inferences, Narosa Publications.
2. Sinha,S.K.(1998): Bayesian Estimation, New Age International(P) Ltd., New Delhi.
3. Leonard,T. And Hsu,S.J. ( ): Bayesian Methods, Cambridge University Press.
4. Berger,J.O.(1985): Statistical Decision Theory and Bayesian Analysis, 2/e Springer Verlag.
5. Christian P. Robert : The Bayesian Choice, 2nd Edition, Springer
6. Robert, C.P. and Casella,G.(2004): Monte Carlo Statistical Methods,2/e Sprienger Verlag.
7. Degroot,M.H.(2004): Optimal Statistical Decesions, Welly Interscience.
8. Gamerman,D. And Lobes,N.F.(200): Stochastic Simulaton for Bayesian Inference,Taylor and Francis.

9. Box,G.P. and Tiao,G.C.(1973): Bayesian Inference in Statistical Analysis, Adison-Wesley.

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|---|---|
| Total Lectures of 1 hour duration | : 45 |
| Total Tutorial classes of 1 hour duration | : 15 |
| Total Credits after calculation | : 4 credits |

**Course No. :** DSE 4 (c) Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Queueing Theory

General concepts: Review of probability, random variables, distributions, generating functions, Basic Characteristics of a queue, Notations, Transient and Steady state, Little's formula, PASTA.
M/M/1 model (Steady and transient state behaviour), Waiting time distribution, Interarrival time distribution, Steady state distribution of M/M/1/k. (12L)

Steady state and waiting time distribution of M/M/c model, Steady state distribution of M/M/c/c, M/M/c//m (m>c) (11L)

Bulk service Queues, Steady state distribution and waiting time distribution of M/M(1,b)/1, M/M(a,b)/1, M/G(1,b)/1, M/G(a, b)/1 models.
(11L)

M/G/1 model: Pollaczek Khinchin and Pollaczek Khinchin Transform Formulae, Steady state distribution and waiting time distribution of GI/M/1 model.
Basic ideas: Queueing system with vacations, Retrial queueing model, Balking and Reneging in the queueing system(without derivation). (11L)

**(45L + 15T)**

**References:**


1. Medhi, J. Stochastic models in queueing theory. Elsevier.
2. Medhi, J. Stochastic processes. New Age International.
3. Feller, W. An Introduction to Probability and its Applications.
4. Parzen, E: Stochastic Processes, Holden-Day.
5. Ross, S. M. Introduction to Probability Models, Wiley publication.
6. Bhat, U. N. Stochastic Models, New age Int., India.
7. Gnedenko, B. V. The Theory of Ptobability, Mir Publishers, Moscow.
8. Chung, K. L. A Course in Probability Theory, Harcourt Brace, New York.
9. Thomopoulos, N. T. Fundamentals of queuing systems: statistical methods for analyzing queuing models. Springer Science & Business Media.
10. Kleinrock, L. Queueing systems, volume 2: Computer applications (Vol. 66). New York: wiley.


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

**Course No. : GE 4** Marks : 100 (In-sem : 40 + End Sem. : 60)

**Title of the Course :** Statistics II

Introduction to Stochastic Process; Classification of Stochastic Processes. Stationary process, Gaussian processes, Stationarity; Markov chains (MC), higher order transition probabilities – Chapman-Kolmogorov theorem, Spectral decomposition; Generating function method, classification of states : transient and recurrent and associated theorem(s); canonical form; Periodicity of Markov Chain; classification of states and of Markov Chain – limiting and stationary distribution of Markov Chain. Absorbing and Non absorbing Markov Chain. Applications of Markov Chain.

(20L)

Markov Process with discrete state space : Poisson process ( time homogenous and non homogenous ), properties and applications; Chapman – Kolmogorov differential equations (backward and forward ), pure birth process, birth – immigration process, birth and death process, linear growth model with immigration, two sex population growth model, immigration – emigration process. (17L)

Queue: Queuing system – general concepts, steady state distribution, Little's formulae, Queuing, models : M/M/I ( steady state and transient state behaviour ); waiting time distribution M/M/I/K, birth and death process in queue : multi channel model – M/M/S; waiting time distribution, M/M/S/S : loss system. (8L)

**(45L + 15T)**

**References:**


1. Medhi, J : Stochastic Processes, third edition, New Age International (p) Ltd. publishers
2. Bhat, U.N. : Stochastic Models, New Age Int., India
3. Adke, S.R. and Manjunath, S.M. : An Introduction to finite Markov Processes, Wiley Eastern.
4. Parzen, E. : Stochastic Processes, Holden-Day.
5. Feller, W.: An Introduction to Probability and its Applications, Wiley
6. Chung, K.L. : A Course in Probability Theory Harcourt Brace, New York.
7. Gnedenko, B.V. : The Theory of Probability, Mir Publishers, Moscow.
8. Ross, S.M : Introduction to probability models , Wiley publication
9. Bartholomew, D.J. : Stochastic Models for Social Processes, Wiley, second edition
10. Ross, S.M. : Stochastic Processes, Wiley


Total Lectures of 1 hour duration : 45
Total Tutorial classes of 1 hour duration : 15
Total Credits after calculation : 4 credits

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