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 21.06.2022 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 21.06.2022 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 4 Credits = 4	1 Course X 2 Credits = 2	22
IV	3 Courses X 4 Credits = 12	1 Course X 4 Credits = 4	---	---	16

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 11	Industrial Statistics	E	4	3	2	5
	DSE 12	Demography	E	4	3	2	5
	DSE 13	Official Statistics	E	4	3	2	5
	AEC 11	Analysis I	E	2	2	1	3
2nd Sem.	C21	Probability Distribution & Reliability	C	4	3	2	5
	C22	Inference-I: Estimation Theory	C	4	3	2	5
	C23	Regression Analysis	C	4	3	2	5
	DSE 21	Quantitative Epidemiology and Biostatistics	E	4	3	2	5
	DSE 22	Operations Research	E	4	3	2	5
	DSE 23	Financial Statistics	E	4	3	2	5
	GE 21	To opt from sister departments	E	4	3	2	5
	GE 22	Statistics – I (To offer to sister Departments)	E	4	3	2	5
3rd Sem.	C31	Inference-II: Testing of Hypotheses	C	4	3	2	5
	C32	Inference –III: Non-Parametric Testing.	C	4	3	2	5
	C33	Stochastic Processes	C	4	3	2	5
	DSE 31	Econometrics	E	4	3	2	5
	DSE 32	Reliability Engineering	E	4	3	2	5
	AEC 31	Analysis II	E	2	2	1	3
	GE 31	To opt from sister departments	E	4	3	2	5
	GE 32	Statistics – II (To offer to sister Departments)	E	4	3	2	5

	GE 33	Statistics – III(To offer to sister Departments)	E	4	3	2	5
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 41	Dissertation	E	4	3	2	5
	DSE 42	Bayesian Inference	E	4	3	2	5
	DSE 43	Queueing Theory	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

DSE_{ij}= j^{th} DSE paper in the i^{th} Semester, i, j = 1, 2, 3, 4

GE_{ij}= j^{th} GE 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

Learning Objective: The main objective of this course is to provide students with the foundations of probabilistic and statistical analysis with reference to the different practical fields

Learning Outcome: It is expected that after completion of the course students are able to relate different real life situations into the probability manners.

It is also expected that this course will serve as a stepping stone for the mathematical statistics papers that the students need to take up in future.

Classes of sets; Algebra of sets; Sequence and Limits of sets; field, σ-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

Learning Objectives: To make the students acquainted with the mathematical tools, which will finally help students formulating/ graduating statistical idea mathematically. The tools would be of immense use in solving statistical problems via mathematical solution and interpreting the solution(s) in words understandable to people. In fine, mathematics teaching is indispensable and inescapable.

***Learning Outcome*:** It is expected that the tools that are incorporated in the syllabi are of great use in analyzing statistical ideas and instilling in students a critical and analytical bent of mind.

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)

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. Matrix application in evaluating multiple integrals. (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. : Real analysis, S.Chand and Co.
5. Rao,C.R. and Mitra, S.K.: Generalised Inverse of matrices and its applications, John Wiley.
6. Spiegel, M.R.: Laplace transforms, Schaum's outline series.
7. Spiegel, M.R.: Algebra of Matrices, Schaum's outline series.
8. Mukhopadhyay, P.: Mathematical Statistics Central, New Book Agency (P) Ltd.
9. Lay, David : Linear Algebra and its applications, Pearson Education
10. Graybill, F.A. : Introduction to matrices with application in Statistics

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

Learning Objectives: To make the students acquainted with computer, which will help the students to use computers in solving different statistical problems. R is widely use in statistical analysis and knowledge of these languages is must for the students to cope up with the world of data analysis. In this course different steps of data processing such as data entry, data editing, data analysis etc. will be discuss using R. Demonstration of these topics will be done by using R.

Learning Outcome: After completion of this course the students will be able expected to learn how to use R in analysis data. It is expected that students will be more confident while handling the data after completion of the course.

R-programming :

Introduction to R, history of R, pros and cons of R, R-studio, R as a calculator, R as a statistical software and language, downloading and installing R, commands, objects and functions, using scripts, the R workspace, installing packages, getting help. Methods of data input, data accessing and indexing, built-in functions, importing data into R,Logical vectors and relational operators, matrix operations in R. (10L+2P)

Descriptive statistics using R, measures of central tendency, measures of dispersions, measures of skewness and kurtosis, correlation and tabulation of data. Handling categorical data with R. (5L+1P)

Visualization of data : standard plot function, arguments, construction of scatter plot, barplot, pie graph, histogram, boxplot, multiple bar diagram etc., visualization of data by using R packages such as ggplot. (5L+1P)

Probability distribution: Probability Distributions (Discrete and Continuous), Estimation of parameters (optim and nlm function) using R. (7L+1P)

Statistical Inference :exploring assumptions using R, different parametric and non-parametric statistical tests. Linear Models using R – Simple Regression, ANOVA, ANCOVA. Logistic Regression with R. (10L+1P)

The Composition of Time series, Detection of Trend, Seasonality and cyclicity, Detrending, forcasting with exponential smoothing and ARIMA

Flow control in R – the for () loop, if () statement, while() loop, repeat loop, break and next statements. Developing own functions in R. Random observation generation from various univariate and multivariate distributions using available functions. Simulation- Definition and fields of application. (8L+1P)

(45L + 15P)

Refernce.

1. Purosit S.G., Gore S.D., Deshmukh S. R. (2008), Statistics using R, Narosa Publishing House
2. Field, A., Miles J., Field Z.(2012), Discovering Statistics Using R, SAGE
3. Dalgaard P.(2002), Introductory Statistics with R, Springer
4. Cohen Y. and Cohen J. Y. (2007), Statistics and Data with R, An Applied Approach Through Examples, Wiley
5. Braun W. J. and Murdoch D. J. (2009) A First Course in Statistical Programming with R, Cambridge

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

Course No. : DSE 11 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Industrial Statistics

Learning Objective: Learn about sampling inspection plan and SPRT; learn LPP and different methods for solving LPP; learn Transportation & Assignment problem.

Learning Outcome:

Statistical Quality Control: Process and Product control; sampling inspecting plan: double sample, sequential sample; SPRT.

Operation Research: Linear programming problem (LPP). Graphical method and simplex method for solving LPP. Transportation problem & Assignment problem.

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 12 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Demography

Learning Objective: To increase the knowledge and understanding of terminology, techniques related to demography, its impact on economy, growth health of a population and to ensure skills to analyse demographic data.

Learning outcome: Summarise and present population data in elegant, systematic way, integrate results to calculate the magnitude and direction of fertility growth of population, burden of diseases, health of women and child in a society. Apply their skills to monitor effectively as health professional or population scientists and prepare reports for future course of action which will be used by planner and policy makers. Build probability models to quantify the risk of insurance system.

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 13 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Official Statistics

Learning Objectives: *To provide a basic idea of about the official statistics system of the nation through different statistical sources like data, graph and maps etc.*
Learning Outcome: *ON competition of this course students are able to understand the prevailing statistical system and how it helps in implementation of plannings in national and state level also how decision making, evaluations and assessments at different levels are carried out.*

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. : AEC 11 Marks : 50 (In-sem : 20 + End Sem. : 30)

Title of the Course : Analysis I

Learning Objective: To make students familiar with algebra of complex numbers and calculus of complex valued functions.
Learning Outcome: The students with statistics background will feel confident in dealing with many aspects of distribution theory, sampling distributions and probability theory in general.

Algebra of complex numbers: Geometric interpretation, sum equality, products, additive and multiplicative identities and inverses. n^{th} root of unity. Conjugate. Topological properties sequence. Disconnected set. (4L)
Complex function as mutlivalued function. Limit. Continuity. Differentiability. Partial and directional derivatives. Cauchy- Riemann equations, Power series. Analytic function. Periodic function. Complex logarithm and power. Abel's limit theorem. (10L)
Integration: Arc, Contour, Cauchy integral theorem. Residue calculus. Laurent Series. Taylor expansion. Mobius transformation. (8L)

(22L + 8T)

References:

1. Sharma J.N.. Functions of a Complex Variable. Krishna Prakasan Media (P) Ltd
2. Spiegel. Murray R., Theory and Problems of Complex Variables with an introduction to Conformal Mapping and its application. Schaum's Outline Series.
3. Kasana, H.S. : Complex Variable – theory and applications, Prentice Hall of India.

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

Learning Objectives: *To build up the mathematical background to deal with multivariate, probability distribution and related methodologies. Derivation of Truncated, Mixture and generalized distributions, Sampling distribution. To introduce basic concepts of reliability.*

Learning Outcome: *After completing the course, students should have developed knowledge of dealing with multivariate probability distributions and investigate their characteristics. Further students will have basic background of 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 χ^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 : Inference I: Estimation Theory

Learning Objectives: Able to understand basic needs, concepts and principles of statistical estimation theory, so as to apply to the concepts in applications. Able to pursue advanced course in estimation.

Learning Outcome: Introduce basic concepts of estimation. Different criteria for choosing best estimator large sample results of estimation. Methods of estimation. Construction of confidence Interval: different methods and approximations. Introduction Bayesian estimation.

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 χ^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

Learning Objectives: *To build up the knowledge of different statistical/ mathematical models and their application in real life.*

Learning Outcome: *After completion of the course students will able to know the theoretical developments of different regression models and their applications in the real life.*

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 21 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Quantitative Epidemiology & Biostatistics

Learning Objective*:* To make students acquainted with different terminology related to quantitative epidemiology, biostatistics and to ensure skills and ability to analyse data with different statistical techniques appropriate for this special area of study.

Learning outcome: Communicate effectively with the persons in the field of medicine and health sciences who need satisfaction to solve their problems and, can take part in collaborative research work in epidemiology, pharmaceutical industry, medical research and other health and disease studies. The skills increase the employability of a student by manifold as they can enter to a field which is so fertile and dynamic.

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 22 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Operations Research

Learning Objective: The main objective of this course is to impart knowledge in concepts and tools of Operations Research, understand mathematical models used in Operations Research and to apply these techniques constructively to make effective business decisions.
Learning Outcome: After successful completion of this course, the students will able to identify and develop operational research models from the verbal description of the real system, understand the mathematical tools that are needed to solve optimization problems and the use of mathematical software to solve the proposed models.

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. : DSE 23 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Financial Statistics

Learning Objectives: To study and analyse financial problems using statistical tools.

Learning Outcome: The students will be able to learn:

- ➢ Understanding the importance Finance Statistics, why and what,
- ➢ Understanding about indicators of Economic growth: GDP, GDCF, FCI/FCO.
- ➢ Understand the growth with the help of Regression and Time Series Analysis

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 22 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Statistics I

Learning Objective: Designed for the students of other disciplines to train them about some basic concepts of Statistics along with its applications in different fields.
Learning outcomes: Proper planning and execution of a statistical survey with scientific methods and handling of different types of data i.e., summarisation or tabulation of data, analysis and presentation of the data with figures and to make appropriate statistical inference using different Statistical tests.

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. Univariate frequency distribution, outliers and extremes, Struge's formula. (10L)

Diagramatic representation of data. Graphical presentation with histogram, frequency curve, box plot and ogive. Summary measures - mean, median, mode, standard deviation, moments, coefficient of variation, skewness and kurtosis.

(10L)

Bivariate frequency distribution: scatter diagram. Linear correlation and regression in bivariate setup. Correlation and causation. Correlation of ranked data. (6L)

Definition of population and sample. Census and sample survey. Types of sampling. Techniques of sampling – simple random sampling, stratified random sampling, systematic sampling and cluster sampling. (6L)

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

(13L)

(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. Gupta, S. C., Kapoor, V. K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons
4. Gupta, S. C., Kapoor, V. K.: Fundamentals of Statistics, Sultan Chand & Sons, Himalaya Publications House.
5. Medhi, J, Statistical Methods.

6. Spiegal, H. R Stephens L. J : Theory and problems of statistics.
7. 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 : Inference II: Testing of Hypotheses

Learning objectives: Introduce basic concepts of testing statistical hypotheses starting with definition of different types of hypothesis, types of errors, critical region. Study different types of critical regions, their applications and construction based on Neyman-Pearson lemma. To understand randomised tests in discrete setup to attain exact size. Know useful properties of tests like monotonicity, invariance etc. To understand the likelihood ratio tests, sequential probability ratio tests and properties.

***Learning outcome*:** Able to formulate appropriate hypotheses, identify and construct / prescribe best tests using alternative methods, conduct experiments to test the hypothesis and interpret the findings. Able to carry out sequential tests when it's appropriate, interpret the results. Ready to do higher level courses on 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 : Inference III: Non-parametric Inference

Learning Objective: Nonparametric inference is one of the important courses in statistics. It refers to statistical techniques that use data to infer unknown quantities of interest while making as few assumptions as possible. Tropically, this involves working with large and flexible infinite dimensional statistical models. The flexibility and adaptability provided by nonparametric techniques is especially valuable in modern statistical problem of current era of massive and complex data sets. Nonparametric techniques are used various areas of sciences like biological science, medical science, psychology, education, pharmaceutical science, social sciences etc.

Learning Outcome: The course taught in M.Sc in statistics, D.U. covers most of the techniques of test procedures necessary for hypothesis testing and decision making. By study the course student will be able to learn many techniques which are useful for solution of inferential problems arise in a day life, research work, various industrial problems etc.

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

Learning Objective: The main objective of this course is to provide the students with the theoretical and practical aspects of working with stochastic (random) processes.
Learning Outcome: After successful completion of this course, it is expected that students will acquire knowledge about basic concepts of the theory of stochastic processes, their properties and be able to apply methods of description and analysis of stochastic models to specific problems.

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 31 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Econometrics

Learning Objective: To develop a way of thinking economic theories in quantitative terms and increase the knowledge of econometric models and learn how to estimate them in different circumstances and forecast future outcomes.
Learning outcomes: Better understanding of economic issues, figure out useful information about important economic policy, test theories, process and present economic data using appropriate statistical methods of inference, explores the relationship between statistical analysis and empirical content, analyzes economic variables using mathematical models to make predictions and forecast future financial or economic trends, estimation of different type of econometric models under different incompatible situations.

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 32 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Reliability Engineering

Learning Objective: Introducing the basic structures of different systems, detailed inference with incomplete data and different real life applications to the students.
Learning Outcome: The students will get exposure on an interesting branch of Industrial Statistics. The students are also expected to get a broader view of the theory and applications of point estimation.
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 31 Marks : 50 (In-sem : 20 + End Sem. : 30)

Title of the Course : Analysis II

Learning Objective: To make students familiar with metric spaces, vector spaces and normed linear spaces. The broader perspective is to inculcate the beauty and strength of abstraction in mathematics.

Learning Outcome: The students with statistics background are expected to be confident in dealing with many aspects of probability theory, linear models and statistical inference.

Metric spaces: Definition and examples. Topological properties: open set, closed set, open and closed ball, closure of a set. Convergent sequence, Cauchy sequence, completeness (6L)

Field: Definition and examples. Gallois field (2L)

Vector space over a field. Normal linear space. Banach space. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Linear operators. Linear functionals. (10L)

Inner product spaces. Orthonormal sets and sequences. Legendre, Hermite and Laguerre polynomials. (4L)

(22L+8T)

References:

1. Irwin Kreyazig. Wiley, Introductory functional analysis with applications.
2. Kumaresan. S., Topology & Metric Spaces.

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

Course No. : GE 32 **Marks: 100 (In-Sem: 40+ End Sem: 60)**

Title of the Course : Statistics-II

Learning Objective: Designed for the students of other disciplines who have already opted for GE 22 (Statistics I) course or who have basic knowledge in statistics with an aim to train the students regarding different statistical inferential procedures.
Learning Outcome: Formulate scientific research problem and solve them effectively with data (with added computer skills) to make appropriate statistical inferences for research work, planning and execution of projects in Government and non-Government organization, industry, financial and management institutions.

Definition of hypothesis, statistical hypothesis. The role of hypothesis in scientific investigation. Testing of statistical hypothesis: Definition of estimator and estimate, Different steps involved in a hypothesis testing problem, definition of parameter and statistic, null and alternative hypothesis, one-tail and two-tail tests, type-I and type-II errors, ideas of level of significance, p-value and confidence interval, Basic principles in determination of sample size in scientific enquiry, simple illustration(s). (12 L)
Parametric Tests: Student's t-test for single mean, equality of two means, paired t-test, correlation and regression coefficient. Large sample tests for single mean and single proportion, equality of two means and two proportions. x^2 tests for independence of attributes. F-tests for equality of two population variances, several population means (ANOVA). (16L)
Concept of Non Parametric (NP) tests. Necessity of NP tests. Advantages and disadvantages of NP tests, over parametric tests. Use of order and rank of observations in NP tests. One sample tests- sign test, sign-rank test, median test, Kolmogorov- Smirnov test for goodness fit, two independent sample tests- run test, median test, Mann-Whitney U-test. Two related sample test- Wilcoxon matched pair sign-rank test. k (>2) independent sample test- Kruskal Walli's test. (11L)
Idea of Multiple linear regression analysis and its uses. Interpretation of parameters and relevant formulae for 3 variable case. Use of matrix method for estimating parameters in 3 variable case. (6L)

(45L+15T)

References:

1. Kale, B.K: A first course on parametric inference, Narosa Publishing House.
2. Gupta, S. C., Kapoor, V. K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons
3. Gibbons, J. D.: NP Statistical Inference, McGrawHill.
4. Gupta, S. C., Kapoor, V. K.: Fundamentals of Statistics, Sultan Chand & Sons, Himalaya Publications House.
5. Conover, W.J: Practical NP Statistics, John Wiley & Sons.
6. Agarawal, B. L.: Basic Statistics, New Age, International.

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

Course No. : GE 33 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Statistics III

Learning Objective: The main objective of this course is to provide the students with the theoretical and practical aspects of working with stochastic (random) processes.
Learning Outcome: After successful completion of this course, it is expected that students will acquire knowledge about basic concepts of the theory of stochastic processes, their properties and be able to apply methods of description and analysis of stochastic models to specific problems.

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

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

Title of the Course : Multivariate Methods

Learning Objectives:

To make the students acquainted with multivariate data and multivariate statistical methods, which will help the students to deal with multi-dimensional data. Multivariate statistical methods are widely used in dealing multi-dimensional data arise in different field of study viz., biological sciences, social sciences, pharm. Sciences, medical sciences, physical sciences, education etc. In this course different methods such as principal component analysis, factor analysis, discriminate analysis etc. will be discussed.

Learning outcome:

It is expected that after completion of this course students will be able to learning handling multivariate data. It is also expected that students will also be able learn how to use different multivariate methods under different situations.

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 - λ 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

Learning Objective: Design of experiment is a process of planning a study to meet specified objective. Design of experiments (DOE) is a systematic method to determine the relationship between factors affecting a process and output of the process. In other words, it is used to find cause and effect relationship. The information is needed to manage process inputs in order to optimize the output. An understanding of design of experiment first requires knowledge of some statistical tools and experimentation concepts. Although a DOE can analyzed in many software programs, it is important to practioners to understand basic DOE concepts for proper applications.

Learning Outcome: The syllabus of M.Sc Statistics, D.U. include various topic of DOE with different tools and techniques necessary for data analysis. Student will be benefited by studying this important courses which are very much used in agricultural fields, industry, various research organizations etc.

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

Learning Objective: Learn basic analysis of time series data; learn to test stationarity; learn basic concepts in time series regression; learn auto-regressive and model averaging models; learn exponential smoothing techniques.
Learning Outcome: Stochastic and deterministic trend, seasonality, correlogram; Probability models for time series: stationarity; Moving average (MA), Autoregressive (AR), ARMA and ARIMA models; Estimating the autocorrelation function and fitting ARIMA models; Forecasting: Exponential smoothing, Forecasting from ARIMA models; Stationary processes in the time domain.

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, 6th 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 41 **{**Marks : 100 (Presentation & Viva-Voce : 40 + Dissertation. : 60)}

Title of the Course : Dissertation

Learning Objective: Introducing dissertation in PG classes is an attempt to instil and infuse in students the scientific temper for pursuing research/ projects and to train them how to write research proposal/ case study proposal, how to get engaged with the methodology/ theory associated with the proposal(s), how to collate and synthesize data/ facts/ ideas, how to critically analyze and present the results and findings of the proposals/ case studies, and how to report the outcome of the whole proposal to academic/ public domain.

Learning Outcome: It is expected that the students would be able to reach out to the ideas/ methods/ theories associated with the proposals/ case studies. Getting through the dissertation/ case study proposal will surely help the students reinforcing their knowledge domain and help gaining traction in their career.

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 42 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Bayesian Inference

Learning Objective: Advancing the students to an established yet much-to-explore paradigm of statistical inference with adequate theory and hands-on practical sessions on computing.

Learning Outcome: The students are expected to approach any statistical problem with a Bayesian point of view.

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.

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

Course No. : DSE 43 Marks : 100 (In-sem : 40 + End Sem. : 60)

Title of the Course : Queueing Theory

Learning Objective: The main objective of this course is to give a working knowledge of queuing models, a description of the underlying theory and examples of their applications in the area of communication, transport and management.

Learning Outcome: After successful completion of this course, the students will able to develop more efficient systems, processes, pricing mechanisms, staffing solutions, and arrival management strategies to reduce customer wait times and increase the number of customers that can be served.

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

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