VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS)

MAJOR and MINOR IN STATISTICS

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes

(CCFUP), 2023 & NEP, 2020

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VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN STATISTICS
(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	1st	I	SEMESTER-I							
			Major-1	STSHMJ101	T: Descriptive Statistics-1 & Probability Theory-1; P: Practical	4	3-0-1	15	60	75
			SEC-1	STSSEC101	P: Statistical Computing using MS Excel	3	0-0-3	10	40	50
			AEC	AEC101	Communicative English -1 (*common for all programmes*)	2	2-0-0	10	40	50
			MDC	MDC101	Multidisciplinary Course -1 (*to be chosen from the list*)	3	3-0-0	10	40	50
			VAC	VAC101	ENVS (*common for all programmes*)	4	2-0-2	50	50	100
			Minor-1 (Disc.-I)	STSMI101	T: Statistical Methods; P: Practical *(To be taken by students of other Disciplines)*	4	3-0-1	15	60	75
					Semester-I Total	20				400
		II	SEMESTER-II							
			Major-2	STSHMJ102	T: Descriptive Statistics-2 & Probability Distributions-1; P: Practical	4	3-0-1	15	60	75
			SEC-2	STSSEC02	P: Statistical Computing using C/C++ Programming	3	0-0-3	10	40	50
			AEC	AEC102	MIL-1 (*common for all programmes*)	2	2-0-0	10	40	50
			MDC	MDC102	Multidisciplinary Course-02 (*to be chosen from the list*)	3	3-0-0	10	40	50
			VAC	VAC02	Value Added Course-02 (*to be chosen from the list*)	4	4-0-0	10	40	50
			Minor-2 (Disc.-II)	STSMI102	T: Introductory probability; P: Practical *(To be taken by students of other Disciplines)*	4	3-0-1	15	60	75
			Summer Intern.	CS	Community Service	+4	0-0-4	-	-	50
					Semester-II Total	24				400
					TOTAL of YEAR-1	44				800

MJ = Major, MI = Minor Course, SEC = Skill Enhancement Course, AEC = Ability Enhancement Course, MDC = Multidisciplinary Course, VAC = Value Added Course; CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical, MIL = Modern Indian Language, ENVS = Environmental Studies

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(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	2nd	III	SEMESTER - III							
			Major-3	STSHMJ03	T: Linear Algebra and Numerical Analysis;	4	4-0-0	15	60	75
			Major-4	STSHMJ04	T: Probability Distribution – II and Limit Theorems; P: Practical	4	3-0-1	15	60	75
			SEC-3	STSHSEC03	P: Statistical Computing with R	3	0-0-3	10	40	50
			AEC	AEC01	Communicative English - 2 (*common for all programmes*)	2	2-0-0	10	40	50
			MDC	MDC03	Multidisciplinary Course -1 (*to be chosen from the list*)	3	3-0-0	10	40	50
			Minor-3 (Disc.-I)	STSMIN03	T: Basics of Statistical Inference; P: Practical; *(To be taken by students of other Disciplines)*	4	3-0-1	15	60	75
					Semester - III Total	20				375
		IV	SEMESTER - IV							
			Major-5	STSHMJ05	T: Mathematical Analysis;	4	4-0-0	15	60	75
			Major-6	STSHMJ06	T: Sampling Distributions and Index Numbers; P-Practical	4	3-0-1	15	60	75
			Major-7	STSHMJ07	T: Statistical Inference - I; P: Practical	4	3-0-1	15	60	75
			AEC	AEC02	MIL-2 (*common for all programmes*)	2	2-0-0	10	40	50
			Minor-4 (Disc.-II)	STSMIN04	T: Applications of Statistics; P: Practical *(To be taken by students of other Disciplines)*	4	3-0-1	15	60	75
			Summer Internship	Internship/ Apprenticeship (Major Discipline)	*Minimum 8 weeks engagement in local bodies, local industry, NGOs, business organizations, health and allied areas, rural entrepreneurs, local governments (such as panchayats, municipalities), survey, media organizations, artists, crafts persons etc. shall be under the supervision of College.**	4	0-0-4	-	-	50
					Semester - IV Total	22				400
					TOTAL of YEAR-2	42				775

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**** After completing their internship or apprenticeship, students are required to submit a report detailing their work (as per the University's guidelines).***

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VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN STATISTICS
(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	3rd	V	SEMESTER - V							
			Major - 8	STSHMJ08	T: Statistical Inference - II; P: Practical	4	3-0-1	15	60	75
			Major - 9	STSHMJ09	T: Time Series Analysis; P: Practical	4	3-0-1	15	60	75
			Major - 10	STSHMJ10	T: Linear Models; P: Practical	4	3-0-1	15	60	75
			Major (Elect.) - 1	STSHDSE01	T: Research Methodology OR T: Data Base Management Systems; P: Practical	4	3-0-1	15	60	75
			Minor - 5 (Disc. - I)	STSHMIN05	T: Monte Carlo Method; P: Practical *(To be taken by students of other Disciplines)*	4	3-0-1	15	60	75
			Semester - V Total			20				375
		VI	SEMESTER-VI							
			Major - 11	STSHMJ311	T: Demography and Vital Statistics; P: Practical	4	3-0-1	15	60	75
			Major – 12	STSHMJ312	T: Design of Experiments; P: Practical	4	3-0-1	15	60	75
			Major - 13	STSHMJ313	T: Multivariate Analysis; P: Practical	4	3-0-1	15	60	75
			Major (Elect.) - 2	STSHMJ(E) 302	T: Survival Analysis OR T: Operations Research; P: Practical	4	3-0-1	15	60	75
			Minor - 6 (Disc.-II)	STSMIN06	Project work using R and/ or MS-Excel *(To be taken by students of other Disciplines)*	4	0-0-4	15	60	75
			Semester - VI Total			20				375
			TOTAL of YEAR - 3			40				750

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List of Major Courses (MJ)

MJ-1: Descriptive Statistics – 1 and Probability Theory - 1
MJ-2: Descriptive Statistics - 2 & Probability Distributions - 1
MJ-3: Linear Algebra and Numerical Analysis
MJ-4: Probability Distribution – 2 and Limit Theorems
MJ-5: Mathematical Analysis
MJ-6: Sampling Distributions and Index Numbers
MJ-7: Statistical Inference - 1
MJ-8: Statistical Inference - 2
MJ-9: Time Series Analysis
MJ-10: Linear Models
MJ-11: Demography and Vital Statistics
MJ-12: Design of Experiments
MJ-13: Multivariate Analysis

Elective Courses (MJ(E))

Major (Elect.) – 1:	Research Methodology	OR	Data Base Management Systems
Major (Elect.) – 2:	Survival Analysis	OR	Operations Research

Skill Enhancement Courses (SEC)

SEC-1: Statistical Computing using MS Excel
SEC-2: Statistical Computing using C/C++ Programming
SEC-3: Statistical Computing with R

List of Minor Courses (MI)

MI-1: Fundamentals of Statistical Methods
MI-2 Introductory probability
MI-3: Basics of Statistical Inference
MI-4: Applications of Statistics
MI-5: Monte Carlo Method
MI-6: Project work using R and/ or MS-Excel

Internship/Apprenticeship (Major Discipline)

SEM-IV: ***Minimum 8 weeks engagement in collecting data on various environmental, health, or other relevant issues from the local communities/areas through surveys or from the local government or non-government organizations, under the supervision of departmental faculty members, and creating a report based on the statistical analysis of the information gathered (primary data collection is preferable). Students may also go to the industry for their internship for a minimum 8 weeks, and then write a report over their detailed work done in the industry and submit it to the institution.***

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MAJOR (MJ)

MJ-1: Descriptive Statistics-1 & Probability Theory-1 **Credit 04 (Full Marks: 75)**

MJ-1T: Descriptive Statistics-1 & Probability Theory-1 **Credit 03**

Course contents:

Unit 1:
Statistics: Definition and scope, concepts of statistical population and sample. Data: quantitative and qualitative, scales of measurement: nominal, ordinal, interval and ratio. Frequency distribution. Presentation: tabular and graphical, including histogram and ogives.

Unit 2:
Measures of Central Tendency: Mean, Median, Mode. Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation, Gini's Coefficient, Lorenz Curve. Moments, skewness and kurtosis, Quantiles and measures based on them. Stem and Leaf Plot, Box Plot. Outlier Detection. Quantile-Quantile Plot.

Unit 3:
Bivariate data: Definition, scatter diagram, simple correlation, simple linear regression, principle of least squares.

Unit 4:
Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic.
Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

MJ-1P: Descriptive Statistics Lab **Credit 01**

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Karl Pearson correlation coefficient.
7. Correlation coefficient for a bivariate frequency distribution.
8. Lines of regression, angle between lines and estimated values of variables.
9. Stem and Leaf Plot, Box Plot and Q-Q Plot.
10. Application problems based on Classical Definition of Probability
11. Application problems based on Bayes Theorem.

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Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company.
5. Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.
6. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
7. Goon, A.M., Gupta, M.K. & Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press
8. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley
9. Uspensky, J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
10. Cacoullos, T. (1973): Exercises in Probability. Narosa
11. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
12. Ross, S. (2002): A First Course in Probability, Prentice Hall

MJ-2: Descriptive Statistics-2 & Probability Distributions-1 Credit 04 (Full Marks: 75)

MJ-2T: Descriptive Statistics-2 & Probability Distributions-1 Credit 03

Course contents:

Unit 1:

Fitting of some non-linear regression equation, correlation ratio, correlation index, Spearman's Rank correlation, Kendall's rank correlation.

Analysis of Categorical Data: Contingency table, measures of association of attributes, relative risk, odds ratio, Pearson's measure, Goodman-Kruskal's measure.

Unit 2:

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., properties of c.d.f, Mathematical expectation and variance.

Unit 3:

Properties of random variables, pgf, mgf and their properties. Some Inequalities: Cauchy-Schwarz inequality, Markov & Chebyshev inequality.

Unit 4:

Standard discrete distributions: Uniform, Binomial, Poisson, Hypergeometric, Geometric and Negative Binomial. Standard continuous distributions: Rectangular, Normal, Exponential.

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MJ-2P: Descriptive Statistics-2 & Probability Distributions-1 Lab **Credits 01**

List of Practical: Use of Computer Software (Excel/C) is preferable.

1. Spearman's rank correlation.
2. Kendall's rank correlation.
3. Problems on categorical data.
4. Fitting of binomial distributions for given n and p
5. Fitting of binomial distributions after computing mean and variance
6. Fitting of Poisson distributions for given value of lambda
7. Fitting of Poisson distributions after computing mean
8. Fitting of suitable distribution
9. Application problems based on binomial distribution
10. Application problems based on Poisson distribution
11. Fitting of rectangular distribution
12. Fitting of normal distribution
13. Fitting of exponential distribution

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Tukey, J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Publishing Co.
5. Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
6. Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company.
7. Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.
8. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley
9. Goon, A.M., Gupta, M.K. & Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press
10. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley
11. Uspensky, J.V. (1937): Introduction to Mathematical Probability, McGraw Hill
12. Cacoullos, T. (1973): Exercises in Probability. Narosa
13. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics, Griffen
14. Ross, S. (2002): A First Course in Probability, Prentice Hall

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MJ - 3: Linear Algebra and Numerical Analysis **Credit 04 (Full Marks: 75)**

MJ - 3T: Linear Algebra and Numerical Analysis **Credit 04**

Unit 1

Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, Adjoint and inverse of a matrix and related properties.

Unit 2

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX = B, solution sets of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

Unit 3

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Quadratic forms: Classification & canonical reduction. Linear transformation. Applications of Linear Algebra in Statistics.

Unit – 4

Numerical Analysis: Polynomials and Difference (finite and divided) Tables. Approximation of functions and Weierstrass Theorem (statement). Lagrange and Newton formulae for Interpolation. Trapezoidal and Simpson's 1/3 and Simpson's 3/8 Rules for approximations of definite integrals. Approximate solutions of Numerical Equations (in one variable) by Iteration and Newton-Raphson methods. Conditions of convergence. Notion of solution of numerical equations in two variables - concept only).

Reference Books:

- Lay David C (2000): Linear Algebra and its Applications, Addison Wesley.
- Schaum's Outlines (2006): Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition.
- Krishnamurthy, V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
- Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International.
- Gupta, S.C. (2008): An Introduction to Matrices (Reprint). Sultan Chand & Sons.
- Artin, M. (1994): Algebra. Prentice Hall of India.
- Datta, K. B. (2002): Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
- Hadley, G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
- Searle, S. R. (1982): Matrix Algebra Useful for Statistics. John Wiley &Sons.
- Chakraborty, Arnab (2014): Linear Algebra, first edition. Sarat Book House.

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- Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
- Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
- Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Del.
- Scarborough, J.B. (1966): Numerical Mathematical Analysis. Oxford and IBH Publishing.

MJ-4: Probability Distributions – 2 and Limit Theorems: Credit 04 (Full Marks: 75)

MJ-4T: Probability Distributions – 2 and Limit Theorems: Credit-3

Unit – 1

Notion of truncated distribution - binomial, Poisson and normal distributions. Some continuous probability distributions: lognormal, beta, gamma, logistic, double exponential, Cauchy, and Pareto along with their properties.

Unit – 2

Two dimensional random variables: discrete and continuous type, joint, marginal and conditional, p.d.f. and c.d.f. Independence of two variables. Triangular distribution, Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Unit-3

Limit laws: Sequence of random variables, convergence in probability, convergence in mean square and convergence in distribution and their interrelations, W.L.L.N. and their applications, Statement of Central Limit Theorem (C.L.T.) for i.i.d. variates, De-Moivre Laplace Limit theorem, applications of C.L.T.

MJ-4P: Probability Distributions – 2 and Limit Theorems Credit 01

List of Practical: Use of Computer Softwares (Excel/C/R) is preferable.

1. Fitting of lognormal distribution
2. Fitting of gamma distribution
3. Fitting of logistic distribution
4. Fitting of beta distribution
5. Fitting of truncated binomial, Poisson and normal distributions

References

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.

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3. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley.
4. Uspensky, J.V. (1937): Introduction to Mathematical Probability, McGraw Hill.
5. Cacoullos, T. (1973): Exercises in Probability. Narosa.
6. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics, Griffen.
7. Ross, S. (2002): A First Course in Probability, Prentice Hall.
8. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.

MJ - 5: M athematical Analysis **Credit 04 (Full Marks: 75)**

MJ - 5T: M athematical Analysis **Credit 04**

Unit - 1

Representation of real numbers as points on a line, algebraic, order and completeness properties of R (concepts only), bounded and unbounded sets, neighbourhood of a point, supremum and infimum, countable, uncountable sets and uncountability of R.

Functions, Sequences and their convergence, monotonic sequences, bounded sequences, squeeze theorem, limits of r^n, $\left(1+\frac{1}{n}\right)^n$, $n^{\frac{1}{n}}$. Infinite series, positive termed series and their convergence. Tests of convergence: comparison test, ratio test and root test. Absolute convergence of a series, Leibnitz's test for the convergence of alternating series,
conditional convergence.

Unit – 2

Review of limit, continuity and differentiability. Indeterminate form L'Hospital's rule. Rolle's and Lagrange's mean value theorems. Taylor's theorem with Lagrange's form of remainder (without proof). Taylor's series expansions of $sinx, cosx, e^x, (1+x)^n, \log(1+x)$. Maxima and minima of functions. Successive differentiation.

Unit 3

Integral Calculus: definite integral (definition). Statements of properties, Fundamental Theorem of Integral Calculus.

Improper Integral, Beta and Gamma functions: properties and relationship between them.

Unit 4

Functions of two variables and Partial Derivatives. Maxima and Minima of such Functions. Constrained Maximization and minimization, use of Lagrange Multiplier. Double Integral (intuitive-graphical approach), change of order of integration, transformation of variables and Jacobians (statement of relevant theorems and their uses).

Reference Books

- Malik S.C. and Savita Arora (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
- Somasundram, D. and Chaudhary, B (1987): A First Course in Mathematical

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Analysis, Narosa Publishing House, New Delhi.
- Gupta S.L. and Nisha Rani (1995): Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi.
- Apostol, T.M (1987): Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.
- Shanti Narayan (1987): A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
- Singa,l M.K. and Singal A.R (2003): A First Course in Real Analysis, 24th Edition, R. Chand& Co., New Delhi.
- Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
- Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
- Chakraborty, Arnab (2014): Real Analysis, volumes 1,2,3, second edition. Sarat Book House.

MJ - 6: Sampling Distributions and Index Numbers **Credit 04 (Full Marks: 75)**

MJ - 6T: Sampling Distributions and Index Numbers **Credit 03**

Unit 1

Derivation of the sampling distribution of sample mean and variance for a normal population, standard errors of sample mean, sample variance and sample proportion.

Exact sampling distribution: Definition and derivation of p.d.f. of χ^2 with n degrees of freedom (d.f.), nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., additive property of χ^2 distribution.

Exact sampling distributions: Student's and Fisher's t-distributions, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance and limiting form of t distribution.

Snedecor's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance. Distribution of 1/F (n1, n2). Relationship between t, F and $\chi 2$ distributions. Distribution of sample correlation coefficient in the null case.

Unit 2

Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and s^{th} order statistics, distribution of sample median and sample range.

Unit 3

Index numbers: Price, Quantity and Value indices. Construction and uses. Various formulae and their comparisons. Tests for Index Numbers. Chain Index Number. Consumer Price Index Number. Wholesale Price Index. Cost of living index number and Index of Industrial Production

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-methods of construction and uses. Uses and limitations of index numbers.

MJ – 6P: Index Numbers **Credit 01**

List of Practical

1) Construction of price index numbers.
2) Construction of quantity index numbers.
3) Construction of wholesale price index numbers.
4) Construction of cost of living index numbers.
5) Construction of chain base and fixed base index numbers.

Reference Books

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
- Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
- Hogg, R.V. And Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
- Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
- Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
- Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics, Prentice Hall.

MJ - 7: Statistical Inference – 1 **Credit 04 (Full Marks: 75)**

MJ – 7T: Statistical Inference - 1 **Credit 03**

Unit 1

Problems of Statistical Inference: Population & parameter, random sample & statistic, Point and Interval Estimation, Confidence level Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality (statement and applications) and MVB estimators.

Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square and statements of their properties.

Unit 2

Testing of Hypothesis, Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Sampling distribution of a statistic.

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Unit 3

Exact tests and confidence intervals: classical and p-value approaches. Binomial proportion(s), Poisson mean(s), Univariate Normal mean (s), standard deviation(s), Standard tests related to Bivariate normal parameters. Tests of simple linear regression coefficients.

MJ – 7P: Statistical Inference - 1 **Credit 01**

List of Practical

1. Estimation of parameters – Method of Moments and Maximum Likelihood Estimation
2. Testing of significance for single proportion and difference of two proportions.
3. Testing of significance for single Poisson mean and difference of two Poisson means.
4. Testing of significance and confidence intervals for single mean and difference of two means.
5. Testing of significance and confidence intervals for single standard deviation and difference of two standard deviations.
6. Testing of parameters under bivariate normal distribution.
7. Testing of the coefficients of simple linear regression model

Reference Books

- Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Outline of Statistics, Vol. I & II, World Press, Calcutta.
- Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
- Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
- Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
- Mood A.M, Graybill F.A. and Boes D.C, Introduction to the Theory of Statistics, McGraw Hill.
- Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
- Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Lowa State University Press.
- Casella , G. and Berger R.L. (2002).: Statistical Inference, 2nd Edn. Thomson Learning

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MJ - 8: Statistical Inference – 2 **Credit 04 (Full Marks: 75)**

MJ – 8T: Statistical Inference - 2 **Credit 03**

Unit 1

Principles of test of significance: Null and alternative hypotheses (simple and composite),Type-I and Type-II errors, critical region, level of significance, size and power, Most powerful test, uniformly most powerful test, Neyman- Pearson Lemma (statement and proof of sufficiency part only) and its applications to construct uniformly most powerful test, unbiased test (definition only). Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit 2

Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients. Large Sample distribution of Pearsonian $\chi 2$ –statistic and its uses.

Unit 3

Large Sample Theory: Transformations of Statistics to stabilize variance: derivation and uses of Sin^{-1}, square root. Uses of logarithmic and z-transformations.

Large sample standard error of sample moments, standard deviation, coefficient of variation, bl and b2 measures and correlation coefficient, and their uses in large sample tests

MJ – 8P: Statistical Inference – 2 **Credit 01**

List of Practical

1. Most powerful critical region
2. Uniformly most powerful critical region.
3. Power curves.
4. Likelihood ratio tests for simple null hypothesis against simple alternative
5. hypothesis.
6. Likelihood ratio tests for simple null hypothesis against composite alternative
7. hypothesis.
8. Large sample tests- binomial proportion(s) and Poisson means.
9. Large sample tests- Pearsonian $\chi 2$.
10. Large sample tests - Sin-1, square root. Uses of logarithmic and z-transformations

Reference Books

- Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Outline of Statistics, Vol. I & II, World Press, Calcutta.
- Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
- Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.

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- Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
- Mood A.M, Graybill F.A. and Boes D.C, Introduction to the Theory of Statistics, McGraw Hill.
- Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
- Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Lowa State University Press.
- Casella, G. and Berger R.L. (2002).: Statistical Inference, 2nd Edn. Thomson Learning

MJ - 9: Time Series Analysis **Credit 04 (Full Marks: 75)**

MJ – 9T: Time Series Analysis **Credit 03**

Unit 1

Introduction to time series data, application of time series from various fields. Modelling time series as deterministic function plus IID errors: Components of a time series (trend, cyclical and seasonal patterns, random error) Decomposition of time series. Estimation of trend: free hand curve method, method of moving averages, fitting various mathematical curves and growth curves.

Unit 2

Effect of elimination of trend on other components of the time series. Estimation of seasonal component by Method of simple averages, Notions of multiplicative models: ratio to Trend.

Unit 3

Introduction to stochastic modelling: Concept of stationarity. Illustration of how a stationary time series may show temporal patterns, Stationarity in mean. Dickey-Fuller test for stationarity.

Box-Jenkins modelling: Moving-average (MA) process and Autoregressive (AR) process of orders one and two. ACF, PACF and their graphical use in guessing the order of AR and MA processes. Estimation of the parameters of AR (1) and AR (2) using Yule-Walker equations. Conditional Heteroscedastic models-ARCH, GARCH (Concept only)

Unit 4

Forecasting: Exponential smoothing methods, short term forecasting methods: Brown's discounted regression,

MJ – 9P: Time Series Analysis Lab **Credit 01**

Time Series Analysis

List of Practical

1) Plotting a reallife time series, and detecting various features (trend, periodic

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behaviours etc). Suggested data sets:

a) Sun spot data

b) Dollar-Rupee exchange rates

c) Stock market data

2) Fitting and plotting of mathematical curves:
   d) Modified exponential curve
   e) Gompertz curve
3) Fitting of trend by Moving Average Method.
4) Plotting detrended series.
5) Measurement of Seasonal indices Ratio-to-Moving Average method.
6) Plotting ACF and PACF of a given time series.
7) Using Yule-Walker equation to fit AR (1) and AR (2) models to real life data.
8) Forecasting by short-term forecasting methods.
9) Forecasting by exponential smoothing.

Reference Books

- Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
- Kendall M.G. (1976): Time Series, Charles Griffin.
- Brockwell and Davis (2010): Introduction to Time Series and Forecasting (Springer Texts in Statistics) ,2nd Edition.

MJ - 10: Linear Models **Credit 04 (Full Marks: 75)**

MJ - 10T: Linear Models **Credit 03**

Unit 1

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance. Fundamental Theorems on least squares (statements only).

Unit 2

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance in one-way classified data, analysis of variance in two-way classified data with equal number of observations per cell-for fixed effect models. Analysis of variance one-way classified data for random effect models.

Unit 3

Regression analysis: Multiple Regression. Estimation and hypothesis testing in case of simple and multiple regression models. Tests for parallelism and identity, linearity of simple regression.

Analysis of covariance (with one concomitant variable) in one-way classified data and two-way classified data for fixed effect models.

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Unit 4

Regression Diagnostics: Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots.

MJ - 10P: Linear Models Lab **Credit 01**

Linear Models
List of Practicals

1. Simple problems related to estimation of linear parametric functions
2. Tests for Linear Hypothesis.
3. Analysis of Variance of a one-way classified data.
4. Analysis of Variance of a two-way classified data with one observation per cell.
5. Analysis of Variance of a two-way classified data with equal number of observations per cell.
6. Analysis of Variance of a one-way classified data for random effect model.
7. Testing of hypothesis related to simple regression, tests for parallelism and identity
8. Testing of hypothesis related to multiple regression
9. Practical based on residual-based regression diagnostics-Graphical analysis
10. Analysis of Covariance of a one-way classified data with one concomitant variable.
11. Analysis of Covariance of a two-way classified data with one concomitant variable.

Reference Books

- Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
- Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
- Scheffe, H. (1959): The Analysis of Variance, John Wiley.
- Goon, A.M., Gupta, M.K.: Das Gupta, B. (2005), Outline of Statistics, Vol.II, World Press, Calcutta.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.

MJ - 11: Demography and Vital Statistics **Credit 04 (Full Marks: 75)**

MJ – 11T: Demography and Vital Statistics **Credit 03**

Unit 1

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekaran-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

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Unit 2

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

Unit 3

Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.-

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR).

Unit 4

Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR). Population Estimation, Projection and Forecasting: Use of A.P. and G.P. methods for population estimates, Fitting of Logistic curve for population forecasting using Rhode's method.

MJ – 11P: Demography and Vital Statistics **Credit 01**

List of Practical

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:-
    a. Direct method
    b. Indirect method
3. To construct a complete life table.
4. To fill in the missing entries in a life table.
5. To calculate CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. To calculate GRR and NRR for a given set of data and compare them.
8. Population Estimation.

Reference Books

- Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
- Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
- Keyfitz, N and Caswell. H (2005): Applied Mathematical Demography (3rd edition), Springer.
- Chattopadhyay, A.K. and Saha, A.K. (2012): Demography: Techniques and

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Analysis, Viva Books.

- Ramakuar, R. and Gopal, Y.S. (1986): Technical Demography. Wiley Eastern Ltd.

MJ - 12: Design of Experiments **Credit 04 (Full Marks: 75)**

MJ - 12T: Design of Experiments **Credit 03**

Unit 1

Experimental designs: Role, historical perspective, terminology: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher). Uniformity trials, fertility contour maps, choice of size and shape of plots and blocks in Agricultural experiments. Uses in Industrial Experiments.

Unit 2

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency. Analysis with one missing observation in RBD and LSD.

Unit 3

Factorial experiments: advantages, notations and concepts. 2^n experiments: design and analysis. Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate.

Unit 4

Split Plot Design and Strip arrangements.

MJ – 12P: **Design of Experiments** **Credit 01**

List of Practicals

1. Analysis of a CRD.
2. Analysis of an RBD.
3. Analysis of an LSD.
4. Analysis of an RBD with one missing observation.
5. Analysis of an LSD with one missing observation.
6. Analysis of 2^2 and2^3 factorial in CRD and RBD.
7. Analysis of a completely confounded two- level factorial design in 2 blocks.
8. Analysis of a completely confounded two- level factorial design in 4 blocks.
9. Analysis of a partially confounded two- level factorial design.
10. Analysis of a single replicate of a 2^n design.
11. Analysis of Split Plot and Strip Plot designs.

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Reference Books

- Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
- Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
- Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
- Dean, A.M. and Voss, D. (1999): Design and Analysis of Experiments. Springer Texts in Statistics.
- Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
- Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.

MJ - 13: Multivariate Analysis **Credit 04 (Full Marks: 75)**

MJ - 13T: Multivariate Analysis **Credit 03**

Multivariate Analysis

Unit 1

Multivariate Data: multiple linear regression, multiple polynomial regression, multiple and partial correlation coefficients.

Unit 2

Random Vector: Probability mass/density functions, Distribution function, mean vector & Dispersion matrix, Marginal & Conditional distributions. Multiple and partial correlation coefficient.

Unit 3

Multivariate normal distribution and its properties, multinomial distribution and its properties, tests for multiple and partial correlation coefficients.

Unit 4

Applications of Multivariate Analysis: Principal Components Analysis and Factor Analysis (Application Oriented discussion, derivations not required)

MJ-13P: Multivariate Analysis **Credit 01**

List of Practical

1. Test for Multiple Correlation.
2. Test for Partial Correlation.
3. Multivariate Normal Distribution.

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4. Principal Components Analysis.
5. Factor Analysis.

Reference Books:

- Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
- Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
- Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
- Johnson, R.A. And Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
- Mukhopadhyay, P.: Mathematical Statistics.
- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
- Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

MJ (E) - 1: Research Methodology **Credit 04 (Full Marks: 75)**

MJ (E) – 1T: Research Methodology **Credit 03**

Unit 1

What is Research? Role of Research in important areas. Characteristics of Scientific Method. Process of research: Stating Hypothesis or Research question, Concepts & Constructs, Units of analysis & characteristics of interest, Independent and Dependent variables, Extraneous or Confounding variables. Measurements and scales of Measurements. Types of research: Qualitative & Quantitative Research, Longitudinal Research, Survey & Experimental Research.

Unit 2

Survey Methodology and Data Collection, sampling frames and coverage error, non- response.

Unit 3

Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation: Fitting of discrete and continuous distributions, fitting of linear and multiple linear regression models, multiple and partial correlation coefficients. Use of Box plot and Quantile-Quantile plot. Exact tests of the parameters of Binomial, Poisson, Normal and Bivariate Normal distributions. Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients.

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Unit 4

Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), questions and answers in surveys, Internal & External validity, interpret the results and draw inferences. Formats and presentations of Reports – an overview.

MJ (E) – 1P: Research Methodology Credit 01

List of Practical: Using Computer Software (MS-Excel/C/R)

1. Fittings of discrete distributions
2. Fittings of continuous distributions
3. Fittings of truncated binomial, Poisson and normal distributions
4. Fittings of simple linear regression model
5. Fittings of multiple linear regression models
6. Exact tests for the parameters of binomial, Poisson, normal and bivariate normal distributions
7. Large sample tests- binomial proportion(s) and Poisson means.
8. Large sample test for correlation coefficient
9. Use of Box plot and Q-Q plot.

Reference Books

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.
3. Mukhopadhyay, P.: Mathematical Statistics.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
5. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
6. Tukey, J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Publishing Co.
7. Das, N.G. : Statistical methods (Vol-I and II)

OR

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MJ (E) - 1: Data Base Management Systems **Credit 04 (Full Marks: 75)**

MJ (E) - 1: Data Base Management Systems **Credit 03**

Data Base Management Systems

Unit 1

Introduction: Overview of Database Management System, Introduction to Database Languages, advantages of DBMS over file processing systems.

Unit 2

Relational Database Management System: The Relational Model, Introduction to SQL: data definition, aggregate function, Null Values, nested sub queries, Joined relations. Triggers, Working with relations of RDBMS: Creating relations e.g. Bank, College Database (create table statement).

Views: Introduction to views, data independence, security, updates on views, comparison between tables and views

Unit 3

Modifying relations (alter table statement), Integrity constraints over the relation like Primary Key , Foreign key, NOT NULL to the tables, advantages and disadvantages of relational Database System.

Unit 4

Database Structure: Introduction, Levels of abstraction in DBMS, View of data, Role of Database users and administrators, Database Structure: DDL, DML, Data Manager (Database Control System).Types of Data Models Hierarchical databases, Network databases, Relational databases, Object oriented databases.

MJ (E) - 1P: Data Base Management Systems Lab **Credit 01**

Data Base Management Systems Lab

List of Practical

1. Design a Database and create required tables. For e.g. Bank, College Database
2. Apply the constraints like Primary Key , Foreign key, NOT NULL to the tables.
3. Write a sql statement for implementing ALTER,UPDATE and DELETE
4. Write the queries to implement the joins
5. Write the query for implementing the following functions: MAX(),MIN(),AVG(),COUNT()
6. Write the query to implement the concept of Intergrity constrains
7. Write the query to create the views
8. Perform the queries for triggers

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9. Perform the operation for demonstrating the insertion , updation and deletion using the referential integrity constraints

Reference Books

- Gruber, M(1990): Understanding SQL, BPB publication.
- Silberschatz, A, Korth, H and Sudarshan, S(2011) "Database System and Concepts", 6th Edition McGraw-Hill.
- Desai, B. (1991): Introduction to Database Management system, Galgotia Publications.

MJ (E) - 2: Survival Analysis **Credit 04 (Full Marks: 75)**

MJ (E) - 2T: Survival Analysis **Credit 03**

Survival Analysis

Unit 1

Survival Analysis: Functions of survival times, survival distributions and their applications-exponential, gamma, Weibull, Rayleigh, lognormal distributions, and distribution having bath-tub shaped hazard function. Mean Residual Time.

Unit 2

Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples.

Unit 3

Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator. Comparison of two survival functions (Two-Sample Log-Rank test).

Unit 4

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.

MJ (E) - 2P: Survival Analysis Lab **Credit 01**

Survival Analysis Lab

List of Practical

1. Estimation of mean survival time and variance of the estimator for Type I censored

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data.

2. Estimation of mean survival time and variance of the estimator for Type II censored data.
3. Estimation of survival function by Kaplan Meier method.
4. Estimation of survival function by Actuarial method.
5. Test for the equality of two survival functions

Reference Books

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer.
3. Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
4. Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.
5. Kleinbaum, D.G. and Klein, M. (2012): Survival Analysis, 3rd Edition, Springer.

OR

MJ (E) - 2: Operations Research **Credit 04 (Full Marks: 75)**

MJ (E) – 2T: Operations Research **Credit 03**

Operations Research

Unit 1

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method.

Unit 2

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.

Unit 3

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game Matrix and solution to rectangular game with mixed strategy.

Unit 4

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

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MJ (E) – 2P: Operations Research Lab **Credit 01**

Operations Research Lab

List of Practical (Using TORA/WINQSB/LINGO)

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation
    a. Degenerate solution
    b. Unbounded solution
    c. Alternate solution
    d. Infeasible solution
3. Allocation problem using Transportation model.
4. Allocation problem using Assignment model.
5. Problems based on game matrix.
6. Graphical solution to mx2 / 2xn rectangular game.
7. Mixed strategy.
8. To find optimal inventory policy for EOQ models and its variations.
9. To solve all-units quantity discounts model.

Reference Books

1. Taha, H. A. (2007): Operations Research: An Introduction, 8 Hall of India.
2. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research-Concepts and cases, 9th Edition, Tata McGraw Hill.

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SEC 1: Statistical Computing using MS Excel **Credits 03 (Full Marks: 50)**

SEC1P: Statistical Computing using MS Excel

Course Outline:

Unit 1: MS-Excel using toolbar

Concept of spreadsheet, General operation on cells, Data handling and cleaning using filtering, conditional formatting, merge and wrap, sort, text to columns, freeze panes, commenting, data validation, removing duplicates, grouping of data, pivot table and data summarization, importing data into excel, protecting excel worksheet and file.

Unit 2: MS-Excel Functions

Statistical functions, Mathematical functions, logical functions, text functions, lookup and reference functions, date and time functions

Unit 3: Graphs and Charts using MS-Excel

Different types of excel charts such as Line, Bar, Scatter, Pie, Box and Whiskers, Waterfall, Histogram, Area. Some advanced charting techniques using excel. Generation of some special charts using excel: Stem and leaf chart, Lorenz curve, Step diagram, Frequency curve, Population pyramid.

Unit 4: Macro and solver

Concept of Excel macro, creating simple excel macro.
Concept of excel solver, solving some linear and nonlinear equations using excel solver.

Unit 5: Data analysis using MS-Excel
Different descriptive statistics for a dataset: Measures of central tendency, dispersion, skewness and kurtosis, Correlation. Regression analysis. Random number generation from Uniform, Binomial, Poisson, Normal.

Suggested Readings:

1. Microsoft Excel Bible: The Comprehensive Tutorial Resource, Michael Alexander, Dick Kusleika, Wiley.
2. Excel ALL-IN-ONE for Dummies, Paul McFedries, Greg Harvey, Wiley.
3. Excel: Quickstart Guide from Beginner to Expert, William Fischer.
4. Statistical Analysis with Excel for Dummies, Joseph Schmuller, Wiley.
5. https://www.excel-easy.com/
6. https://www.w3schools.com/excel/index.php

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SEC 2: Statistical Computing using C/C++ Programming **Credits 03 (Full Marks: 50)**
SEC 2P: Statistical Computing using C/C++ Programming

Course Outline:

Unit 1: Introduction

Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data.

Unit 2: Flow control

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional (?) operator.
Looping in C/C++: for, nested for, while, do…while, and jumps in and out of loops.
Arrays: Declaration and initialization of one-dim and two-dim arrays.

Unit 3: Functions, Pointer and Files

User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions: no arguments and no return values, arguments but no return values, arguments with return values, no arguments but returns a value, functions that return multiple values.

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers.
File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

Unit 4: Statistical computing: some suggested programs

- Finding values of a function $y = (x)$ for given values of x.
- Roots of a quadratic equation (with imaginary roots also).
- Sorting of an array
- Preparing grouped and ungrouped frequency table
- Different measures of central tendency for series data and frequency data
- Different measures of dispersion for series data and frequency data
- Different measures of skewness and kurtosis for series data and frequency data
- Computing correlation and fitting of regression lines
- Fitting of exponential curve
- Compute ranks and then calculate rank correlation (without tied ranks)
- Fitting of binomial, poisson distribution

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- Random number generation from uniform, binomial, poisson, exponential and normal. Calculate sample mean and variance and compare with population parameters.
- Obtain cdf of binomial and poisson distribution

Suggested Readings:

- Kernighan, B.W. and Ritchie, D. (1988): C Programming Language,2nd Edition, Prentice Hall.
- Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition Tata McGraw Hill.
- Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill.

SEC-3: Statistical Data Analysis using R **Credits 03**
SEC3P: Statistical Data Analysis using R

Unit 1

Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open source philosophy.
R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers. Standard functions, e.g., sin, cos, exp, log.

Unit 2

The different types of numbers in R: Division by zero leading to Inf or -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c(), seq() and colon operator. How functions map overvectors. Functions to summarize a vector: sum, mean, sd, median etc. Extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting. Plot(), lines(), abline(). No details about the graphics parameters except colour and line width. Barplot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x).

Unit 3

Matrix operations in R: Creation. Basic operations. Extracting submatrices. Loading data from a file: read.table() and read.csv(). Mention of head=TRUE and head=FALSE. Data frames. Mention that these are like matrices, except that different columns may be of different types.

Unit 4

Problems on Linear Algebra. Problems on discrete and continuous probability distributions. Problems on Non-Linear Regression Modeling in one variable.

Reference Books

- Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
- Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York
- A simple introduction to R by Arnab Chakraborty (freely available at http://www.isical.ac.in/~arnabc/)
- R for beginners by Emmanuel Paradis (freely available at ftp://cran.r-project.org/pub/R/doc/contrib/Paradis-rdebuts_en.pdf)

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MINOR (MI)

MI – 1: Fundamentals of Statistical Methods **Credits 04 (Full Marks: 75)**

MI – 1T: Fundamentals of Statistical Methods **Credits 03**

Course contents:

Unit 1:
Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Frequency distribution, Presentation: tabular and graphic, including histogram and ogives.

Unit 2:
Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

Unit 3:
Bivariate data: Definition, scatter diagram, simple correlation coefficient, Statement of rank correlation (Spearman). Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

Unit 4:
Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency table (Case of 2x2 only).

MI – 1P: Statistical Methods Lab **Credits 01**

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Multiple correlations
9. Spearman's rank correlation without ties.
10. Correlation coefficient for a bivariate frequency distribution.
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

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Suggested Readings:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. AndBoes, D.C. (2007): Introduction to the theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Goon A.M., Gupta M.K. and Dasgupta B.: Basic Statistics. The World Press, Kolkata.
5. Chakraborty, Arnab (2016): Probability and Statistics. Sarat Book House.

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MI – 2: Introductory probability **Credits 04 (Full Marks: 75)**

MI – 2T: Introductory probability **Credits 03**

Course contents:

Unit 1:
Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic.

Unit 2:
Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Unit 3:
Random Variables: Discrete and continuous random variables, p.m.f., p.d.f., c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

Unit 4:
Standard probability distributions: Uniform, Binomial, Poisson, Geometric, Rectangular, Normal, Exponential.

MI – 2P: Introductory probability Lab (Practical) **Credits 01**

List of Practical

1. Problems based on area property of normal distribution.
2. To find the ordinate for a given area for normal distribution.
3. Application based problems using normal distribution.
4. Fitting of normal distribution when parameters are given.
5. Fitting of normal distribution when parameters are not given.
6. Problems similar to those in 1 to 5 in case of exponential continuous distributions

Suggested Readings:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi
4. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
5. Chakraborty, Arnab (2016) : Probability and Statistics. Sarat Book House.
6. Ross, S. (2002): A First Course in Probability, Prentice Hall.

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MI3: Basics of Statistical Inference **Credits 04 (FM: 75)**

MI3T: Basics of Statistical Inference **Credits 03**

Course Contents:

Unit 1

Population and Sample, Parameter and Statistic, Population distribution and Sampling distribution.

Statistical Inference: Point Estimation, Interval Estimation and Testing of Statistical Hypothesis. Four useful distributions for statistical Inference; Normal, χ^2, t and F (Statement of the pdf's & shape of the curves). Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems).

The basic idea of significance test. Null and alternative hypothesis. Type I& Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

Unit 2

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test.

Unit 3

Tests for the significance of correlation coefficient. Sign test. Wilcoxon two-sample test.

Unit 4

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, Statistical concepts of "treatment", "plot" and "block".

Analysis of completely randomized design, randomized complete block design.

MI 3P: Basics of Statistical Inference Lab (Practical) **Credits 01**

List of Practical

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.

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10. Wilcoxon two-sample test.
11. Analysis of Variance of a one-way classified data
12. Analysis of Variance of a two-way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

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MI4: Applications of Statistics **Credits 04 (FM: 75)**

MI4T: Applications of Statistics **Credits 03**

Course Contents:

Unit 1

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series.

Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential). Measurement of seasonal variations by method of ratio to trend.

Unit 2

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number & wholesale price index number. Index of Industrial Production and rate of inflation. Uses and limitations of index numbers.

Measures of Inequality and Development: Gini's coefficient and Lorenz curve, Human Development Index.

Unit 3

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates.

Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

MI 4P: Applications of Statistics (Practical) **Credits 01**

List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of Consumer and wholesale price index numbers, fixed base index number and consumer price index number with interpretation.
5. Gini's coefficient, Lorenz curve, Human Development Index.
6. Computation of measures of mortality.
7. Completion of life table.
8. Computation of measures of fertility and population growth

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Suggested Readings:

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9th Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint), Sultan Chand &Sons

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MI 5: Monte Carlo Method **Credits 04 (FM: 75)**

MI-5T: Monte Carlo Method **Credits 03**

Course Contents:

Unit 1

Using the computer for random number generation (treated as a black box). A brief look at some popular approaches (no mathematical justification needed). Simulating a coin toss, a die roll and a card shuffle.

Unit 2

CDF inversion method. Simulation from standard distributions. Finding probabilities and moments using simulation.

Unit 3

Monte Carlo integration. Basic idea of importance sampling. MCMC not included.

Unit 4

Generating from Binomial and Poisson distributions, and comparing the histograms to the PMFs. Generating from Uniform(0,1) distribution, and applying inverse CDF transforms. Simulating Gaussian distribution using Box-Muller method. Approximating the expectation of a given function of a random variable using simulation. Graphical demonstration of the Law of Large Numbers. Approximating the value of pi by simulating dart throwing.

MI-5P: Monte Carlo Method Lab **Credits 01**

List of Practical

1. Random number generation from Binomial distribution.
2. Random number generation from Poisson distribution.
3. Random number generation from Uniform distribution.
4. Simulation of Gaussian distribution using Box-Muller method.
5. Finding probabilities and moments using simulation from standard distributions.

Suggested Readings:

1. Shonkwiler, Ronald W. and Mendivil, Franklin (2009):Explorations in Monte Carlo Methods (Undergraduate Texts in Mathematics)
2. Carsey, Thomas M. and Harden, Jeffrey J. (2014): Monte Carlo Simulation and Resampling Methods for Social Science.

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MI 6: Project work using R and/ or MS-Excel **Credits 04 (FM: 75)**

MI-5T: Project work using R and/ or MS-Excel **Credits 03**

Course Contents:

Objective: The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real-life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

Different statistical concepts using R and/ or MS-Excel to be discussed with the students before the project work:

- Descriptive Statistics: Mean, median, mode, variance, measures of skewness & kurtosis, Correlation coefficient
- Representation of data: By different graphs and tables
- Inferential Statistics: Testing of hypothesis in connection with normal distribution (one sample and two sample problems), Some simple nonparametric tests: Sign test, Wilcoxon two-sample test. Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test.
- Regression Analysis: Handling Simple regression, Multiple regression, Logistic regression
- Analysis of variance: One way and two-way classification

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