KOLHAN UNIVERSITY

Chaibasa, Jharkhand, India

Syllabus for
Four Year Undergraduate Programme (FYUGP)
of

Statistics

Major, Minor, MDC, and IAP

Papers

(Semester – I to VIII)

With Effect from Academic Year 2022 - 2023

As Per Revised Curriculum and Credit Framework for the FYUGP
under the provisions of NEP – 2020

KOLHAN UNIVERSITY

Chaibasa, Jharkhand, India

Department of Statistics

Revised Curriculum and Credit Framework as per FYUGP, NEP–2020 for UG Statistics (w.e.f. 2022)

Syllabus of UG Statistics has been prepared by following members of Board of Studies (BOS)

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Part – A

Course Structure for Major

Semester	Course Code	Title of the Paper	Credits	Page
I	MJ-1	Descriptive Statistics	3	6
	MJ-P-1	Practical	1	7
II	MJ-2	Probability Theory	3	8
	MJ-3	Probability Distributions	3	9
	MJ-P-2	Practical	2	10
III	MJ-4	Statistical Inference–I	3	11
	MJ-5	Calculus	3	12
	MJ-P-3	Practical	2	13
IV	MJ-6	Demography and Vital Statistics	3	14
	MJ-7	Sampling Distributions	3	15
	MJ-8	Linear Algebra	3	16
	MJ-P-4	Practical	3	17
V	MJ-9	Applied Statistics–I	3	18
	MJ-10	Statistical Inference–II	3	19
	MJ-11	Design of Experiments	3	20
	MJ-P-5	Practical	3	21
VI	MJ-12	Applied Statistics–II	3	22
	MJ-13	Statistical Computing Using Python Programming	3	23
	MJ-14	Survival Analysis and Biostatistics	3	24
	MJ-15	Mathematical Analysis	3	25
	MJ-P-6	Practical	4	26
VII	MJ-16	Stochastic Process and Queuing Theory	3	27
	MJ-17	Multivariate Analysis	3	28
	MJ-18	Sample Survey and Indian Official Statistics	3	29
	MJ-19	Operations Research	3	30
	MJ-P-7	Practical	4	31
VIII	MJ-20	Actuarial Statistics	3	32
	MJ-P-8	Practical	1	33
	RC	Research Project Dissertation	12	-
	AMJ-1	Linear Models	3	34
	AMJ-2	Econometrics	3	35
	AMJ-3	Data Analytics Using Python	3	36
	AMJ-P-1	Practical	3	37

Note:

1. In Theory Papers 1 Credit = 15 Contact Hours
2. In Practical/Project/Dissertation/Summer Internship/Field Work Papers 1 Credit = 30 Contact Hours
3. MJ – Major, AMJ – Advanced Major, MJ-P – Practical (Major)

Part – B

Course Structure for Minor, MDC, and IAP

Semester	Course Code	Title of the Paper	Credits (Th + Pr)	Page
I	MN-1A	Basic Statistics and Probability	3+1	39
	MDC-1/2/3	Introduction to Statistics	3+0	40
II	MN-2A(VOC)	Data Analysis Using Spreadsheet	3+1	41
III	MN-1B	Statistical Methodology	3+1	42
IV	MN-2B(VOC)	Statistical Data Analysis Using R	3+1	43
V	MN-1C	Theory of Statistical Inference	3+1	44
	IAP	Summer Internship Related to Applied Statistics	4+0	45
VI	MN-2C(VOC)	Statistical Techniques for Research Method	3+1	46
VII	MN-1D	Survey Sampling and Design of Experiment	3+1	47
VIII	MN-2D(VOC)	Database Management System	3+1	48

Note:

1. In Theory Papers 1 Credit = 15 Contact Hours
2. In Practical/Project/Dissertation/Summer Internship Papers 1 Credit = 30 Contact Hours
3. MN – Minor, MDC – Multi Disciplinary Course, VOC – Vocational, IAP – Internship/Apprenticeship/Field Work/Dissertation/Project

Part – A
(Major Papers)

Semester-I -(MJ-1)
Course Title: Descriptive Statistics

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***

UNIT I

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurementnominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

UNIT II

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.

UNIT III

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

UNIT IV

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers.

Suggested Reading:

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. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd. 5

Semester-I-MJ (*Practical-1*)

Max. Marks: 25 ***Credit-1***

List of Practical

1. Graphical representation of data.

2. Problems based on measures of central tendency, dispersion.

3. Problems based on moments, skewness and kurtosis.

4. Fitting of polynomials, exponential curves.

5. Karl Pearson correlation coefficient.

6. Correlation coefficient for a bivariate frequency distribution, Spearman rank correlation.

7. Lines of regression, angle between lines and estimated values of variables.

8. Planes of regression and variances of residuals for given simple correlations.

9. Calculate price and quantity index numbers using simple and weighted average of price relatives.

10. To calculate the Chain Base index numbers and price index number

Semester-II-(MJ-2)
Course Title: Probability Theory

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***

UNIT I

Random experiment, Trial, Sample point and Sample space, Events, Operations of events, Concept of equally likely, mutually exclusive and Exhaustive events. Definition of Probability: Classical, Relative frequency and Axiomatic approaches. Discrete Probability Space, Properties of Probability under Set Theory Approach, Independence of Events, Conditional Probability, Total and Compound Probability theorems, Bayes theorem and its applications.

UNIT II

Random Variables - Discrete and Continuous, Probability Mass Function (pmf) and Probability density function (pdf), Cumulative distribution function (cdf) with properties, Joint distribution of two random variables, Jacobian Transformation for one and two variables with illustrations, Marginal and Conditional distributions, Independence of random variables.

UNIT III

Expectation of a random variable and its properties, Expectation of sum of random variables and product of independent random variables, Conditional expectation and related problems.Moment generating function (m.g.f.) &their properties. Cumulative generating function and characteristic function- Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

UNIT IV

Attributes: Notion and Terminology, Contingency table, Class frequencies and Ultimate class frequencies, Consistency, Association of Attributes, Independence, and Measures of association for 2X2 table, Coefficients of Association.

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (1968). Fundamental of Statistics, Vol I-II, World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics,SultanChand and Sons.
3. Hogg, R.V. and Tanis, E.A. (2008). A Brief Course in Mathematical Statistics. Pearson Education.

Semester-II-(MJ-3)

Course Title: Probability Distribution

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***

UNIT I

Markov, Jensen & Chebyshev's inequalities, Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter-relations, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof).

UNIT-II

Discrete Probability distributions: Bernoulli distribution, binomial distribution, its mean, variance, mode and mgf, recurrence relation for binomial distribution. Definition, moments and mgf.Negative binomial distribution, Poisson distribution and its moments. Poisson distribution as a limiting case of binomial distribution, its mean, variance and mgf, Recurrence relation of Poisson distribution, Poisson distribution as a limiting case of negative binomial distribution recurrence formula for negative binomial distribution. Geometric and Hyper geometric distribution**;** its definition, mean, variance and relation with Binomial distribution

UNIT-III

Rectangular distribution; Moments of rectangular distribution, mgf and mean deviation of rectangular distribution. Normal distribution: its definition, mean, variance and mgf. Properties of Normal curve, simple problems on Normal distribution including area problems, Normal distribution as a limiting case of binomial distribution.

UNIT-IV

Gamma and Beta distribution: Definition and properties of Gamma distribution**,** beta distribution of first kind as well as of second kind, Cauchy and Exponential distribution along with simple illustrations.

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. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

3. Gupta, S.C. andKapoor, V.K. (2020). Fundamentals of Mathematical Statistics,Sultan Chand and Sons.

Semester-II-MJ (*Practical-2*)

Max. Marks: 50 ***Credit-2***

List of Practical

1. Problem based on Probability.
2. Problems based on pmf, pdf & cdf.
3. Computation of conditional probabilities based on Bayes Theorem.
4. Computation of Joint, Marginal & Conditional probabilities.
5. Checking consistency of data and finding association among attributes.
6. Problem based on binomial distributions for n and p=q=1⁄2 given, computing mean and variance.
7. Application problems based on binomial distribution.
8. Application problems based on Poisson distribution.
9. Problems based on area property of normal distribution.
10. Problems based exponential distribution etc.

Semester-III -(MJ-4)

Course Title: Statistical Inference-I

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Point estimation: Families of distributions - location and scale families. Single parameter exponential family. Point estimation. Concepts of estimator and estimate. Criteria for estimators: Unbiasedness, consistency. Invariance property of consistent estimators. Efficiency andrelative efficiency. Mean square error as a criterion for comparing estimators. Sufficient statistic. Statement of Neyman - Factorization theorem. Fisher information function. Statement of Cramer - Rao inequality and its applications. Minimum variance unbiased estimator and minimum bound estimator.

UNIT II

Methods of point estimation: Maximum likelihood and method of moment estimation. Properties of maximum likelihood and moment estimators and examples.

UNIT III

Interval estimation: Confidence interval, confidence coefficient, shortest confidence interval. Method of constructing confidence intervals using pivotal quantity. Construction of confidence intervals for mean, difference of two means, variance and ratio of variances,proportion, difference of two proportions, and correlation coefficient.

UNIT IV

Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

Suggested Readings:

1.Goon A.M., Gupta, M.K., Das Gupta, B. (1991).Fundamentals of Statistics,Vol.I, World Press, Calcutta.
2. Hogg, R. V. and Craig, A.T. (1995).Introduction to Mathematical Statistics, 5/e, Prentice Hall, New Jersey, USA.
3. Medhi, J. (1992).Statistical Methods: An introductory text, New Age International, New Delhi.
4. Montgomery, D.C. and Runger, G.C. (2013). Applied Statistics and Probability for Engineers, WileyIndia, New Delhi.
5. Mukhopadhyay, P.(2015): Mathematical Statistics, Books and Allied (P) Ltd., Kolkata.
6. Spiegel, M.R. (2001).Probability and Statistics, 4/e, Schaum's Outline Series, McGraw Hill, London.
7. Walpole, R.E., Myers, R.H., and Myers, S.L. (2017). Probability and Statistics for Engineers and Scientists, 9/e, Pearson, New Delhi.

Semester-III -(MJ-5)

Course Title: Calculus

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Differential Calculus**:** Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points.

UNIT II

Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

UNIT III

Differential Equations: Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients.

UNIT IV

Formation and solution of simple partial differential equations. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous & Non-homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

Suggested Readings:

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
2. Gorakh Prasad: Integral Calculus, PothishalaPvt. Ltd., Allahabad (14th Edition -2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2nd Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

Semester-III-MJ (*Practical-3*)

Max. Marks: 50 ***Credit-2***

List of Practical

1. Point estimation of parameters and obtaining estimates of standard errors.
2. Comparison of estimators by plotting mean square error.
3. Computing maximum likelihood estimates, moment estimates**.**
4. Constructing confidence intervals based on large samples.
5. Constructing confidence intervals based on small samples.
6. Generating random samples from continuous distributions.
7. Numerical differentiation.
8. Numerical Integration
9. Solution of ordinary differential equation.
10. Solution of Partial differential equation.

Semester-IV -(MJ-6)

Course Title: Demography and Vital Statistics

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Nature and scope of Demography. Population theories – Malthus, Natural and Biological, Demographic transition. Demographic data- sources, coverage and content errors. Use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data- Myer and UN indices. Population composition, dependency ratio.

UNIT II

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 Rates (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates.

UNIT III

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. Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method.

UNIT IV

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Suggested Readings:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.

Semester-IV -(MJ-7)

Course Title: Sampling Distribution

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I
Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof).

UNIT II
Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

UNIT III
Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on distribution.

UNIT IV
Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution.
Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.
***only Central distributions**

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): *An Outline of Statistical Theory*, Vol. I, 4thEdn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4th Edn. John Wiley and Sons.
5. 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.

Semester-IV -(MJ-8)

Course Title: Linear Algebra

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations. Vector spaces, Subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem (without proof).

UNIT II

Algebra of matrices - Types of Matrices: triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices related results and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices.

UNIT III

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, Circulant determinants and Vandermonde determinants for nth order, Jacobi's Theorem, product of determinants. Adjoint and inverse of a matrix and related properties. 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 IV

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations).Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, useful Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms definition and classifications; Linear orthogonal transformation and their diagonalization.

Suggested Readings:

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines : Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition, 2006.
3. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.

Semester-IV-MJ (*Practical-4*)

Max. Marks: 75 ***Credit-3***

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:-
   (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To calculate probabilities of death at pivotal ages and use it construct abridged life table using
   (i) Reed-Merrell Method, (ii) Greville's Method (iii) King's Method
5. To calculate CBR, GFR, SFR, TFR, GRR and NRR for a given set of data
6. Testing of significance and confidence intervals for single proportion and difference of two proportions
7. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
8. Testing of significance and confidence intervals for difference of two standard deviations.
9. Exact Sample Tests based on Chi-Square Distribution.
10. Testing if the population variance has a specific value and its confidence intervals.
11. Testing of goodness of fit.
12. Testing of independence of attributes.
13. Testing based on 2 X 2 contingency table without and with Yates' corrections.
14. Testing of significance and confidence intervals of an observed sample correlation coefficient.
15. Testing and confidence intervals of equality of two population variances
16. Basic Mathematical operations of Matrices.
17. Transpose, Adjoint and Trace of a Matrix.
18. Digonalization of a Matrix.
19. Inverse of a Matrix.
20. Eigen value and Eigen Vector.

Semester-V -(MJ-9)

Course Title: Applied Statistics-I

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher. Factor reversal and time reversal tests. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers.

UNIT II

Introduction to times series data, application of time series from various fields. Components of a times series, Decomposition of time series.

UNIT III

Trend: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, and growth curves. Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series.

UNIT IV

Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend. Ratio to Moving Averages and Link Relative method, Deseasonalization. Random Component: Variate component method.

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. Gupta, S.C. and Kapoor, V. K. (2008): Fundamentals of Applied Statistics, 4th Ed. (reprint), Sultan Chand and Sons.
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. Kendall M.G. (1976): Time Series, Charles Griffin.
5. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
6. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied.

Semester-V -(MJ-10)

Course Title: Statistical Inference-II

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Introduction to tests of hypotheses: Statistical hypotheses- null and alternative, simple and composite hypotheses. Type-I and Type-II errors, test functions. Randomized and nonrandomized tests. Size, level of significance, power function, power of tests. Critical region.p-value and its interpretation. Illustrative examples. Most powerful (MP) test. Statement of Neyman – Pearson lemma and its applications.

UNIT II

Tests of significance I: Large and small sample tests of significance.Tests for single mean, equality of two means, single variance, and equality of two variances for normal populations. Tests for proportions.

UNIT III

Tests of significance II: Tests for simple, partial,and multiple correlation coefficients and regression coefficients. Fisher's Z-transformation and its applications. Analysis of categorical data: contingency tables, tests for the independence andassociation of attributes. Chi-square tests for independence of attributes and goodness of fit.

UNIT IV

Nonparametric tests: Introduction to nonparametric tests. Run test for randomness. Sign test and Wilcoxon signed rank test for one and paired samples. Run test, median test, and Mann-Whitney-Wilcoxon test for two sample problems. Test for independence based on Spearman's rank correlation coefficient.
Sequential tests: Need for sequential tests, Wald's SPRT for binomial proportion and Normal population mean when variance is known.

Suggested Readings:

1. Chandra,T. K. and Chatterjee, D. (2005). A First Course in Probability, Narosa Publishing House, New Delhi..
2. Hogg, R. V. and Craig, A.T. (1995).Introduction to Mathematical Statistics, 5/e, Prentice Hall, New Jersey, USA.
3. Lehmann, E. L. and Romano, J. P. (2005). Testing Statistical Hypotheses, 2/e, John Wiley, NewYork. 3. Montgomery, D.C. and Runger, G.C. (2013). Applied Statistics and Probability for Engineers, Wiley India, New Delhi.
4. Mukhopadhyay, P.(2015): Mathematical Statistics, Books and Allied (P) Ltd., Kolkata.
5. Walpole, R.E., Myers, R.H., and Myers, S.L. (2017). Probability and Statistics for Engineers and Scientists, 9/e, Pearson, New Delhi.

Semester-V -(MJ-11)

Course Title: Design of Experiments

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with single missing observation.

UNIT II

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties.

UNIT III
Factorial experiments: advantages, notations and concepts, 2^2, 2^3…$2^n$and 3^2factorial experiments, design and analysis, Total and Partial confounding for $2^n(n\leq5)$ and 3^2.

UNIT IV

Factorial experiments in a single replicate. Fractional factorial experiments: Construction of one-half and one-quarter fractions of $2^n(n\leq5)$ factorial experiments.

Suggested Readings:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley EasternLtd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

Semester-V-MJ (*Practical-5*)

Max. Marks: 75 ***Credit-3***

List of Practical

1. Analysis of a CRD , RBD and LSD
2. Analysis of an RBD, LSD with one missing observation
3. Intra Block analysis of a BIBD
4. Analysis of 2^2 and2^3 factorial in CRD, RBD and LSD
5. Analysis of a completely confounded two level factorial design in 2 blocks
6. Analysis of a completely confounded two level factorial design in 4 blocks
7. Analysis of a partially confounded two level factorial design
8. Analysis of a single replicate of a 2^n design
9. Analysis of a fraction of 2^n factorial design
10. Evaluation of probabilities of Type-I and Type-II errors and powers of tests.
11. MP test for parameters of binomial and Poisson distributions.
12. MP test for the mean of a normal distribution and power curve.
13. Tests for mean, equality of means when variance is (i) known, (ii) unknown under normality (small and large samples)
14. Tests for single proportion and equality of two proportions.
15. Tests for variance and equality of two variances under normality
16. Tests for correlation and regression coefficients.
17. Tests for the independence of attributes, analysis of categorical data and tests for the goodness of fit.(For uniform, binomial and Poisson distributions)
18. Practical based on nonparametric tests.
19. SPRT for binomial proportion and mean of a normal distribution.
20. Practical based on Time-Series and Index number.

Semester-VI -(MJ-12)

Course Title: Applied Statistics-II

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration.

UNIT II

Statistical Process Control - Seven tools of SPC, chance and assignable causes of quality variation.Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, analysis of patterns on control chart, Control charts for variables: X-bar & R-chart, X-bar & s-chart.

UNIT III

Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

UNIT IV

Acceptance sampling plan: Principle of acceptance sampling plans. Single sampling plan their OC, AQL, LTPD, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

Suggested Readings:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011):Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.
4. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd. and allied (P) Ltd.

Semester-VI -(MJ-13)

Course Title: Statistical Computing using Python Programming

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

History and importance of Python. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a Python program. Data types: Basic data types, Enumerated data types, derived 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 II

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional operator. Looping in Python for, nested for, while, do…while, jumps in and out of loops.
Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT III

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, Recursion function, Passing arrays to functions, Storage class of Variables.

UNIT IV

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.

Suggested Readings:

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2ndEdition,Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
3. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill
4. Kamthane, A.N (2018):Programming and problem Solving with PHTHON, Tata McGraw Hill

Semester-VI -(MJ-14)

Course Title: Survival Analysis and Biostatistics

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Survival Analysis: Functions of survival times, survival distributions and their applicationsexponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function. 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. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT II

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. Theory of independent and dependent risks. Bivariate normal dependent risk model.

UNIT III

Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

UNIT IV

Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array .relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials: Planning and design of clinical trials, Phase I, II and III trials. Single Blinding

SUGGESTED READING:

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.
2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.
3. Kleinbaum, D.G. (1996): Survival Analysis, Springer.
4. Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
5. Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC. B. Sc. Honours (Statistics)

Semester-VI -(MJ-15

Course Title: Mathematical Analysis

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT-I

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

UNIT-II

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence. Indeterminate form, L' Hospital's rule.

UNIT-III

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansions of sin(x), cos(x), log (1+x).

UNIT-IV

Numerical Analysis: Factorial, finite differences and interpolation, Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae, Numerical integration, Trapezoidal rule, Simpson's one-third rule, three-eight rule, Weddle's rule with error terms, Difference equations of first order and their solutions, Solution of Transcendental equations with NR method.

Suggested Readings:

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
2. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi, 1987.
3. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
4. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis(3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
5. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis,Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

Semester-VI-MJ (Practical-6)

Max. Marks: 100 ***Credit-4***

List of Practical

1. Construction and Interpretation of statistical control chart X-bar and R-chart, X-bar and S-chart, np-chart, p-chart, c-chart, and u-chart.
2. Single sample inspection plan: construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.
3. Calculation of process capability and comparison of 3-sigma limits with specification limits.
4. To estimate survival function
5. To determine death density function and hazard function
6. To identify type of censoring and to estimate survival time for type I and type II censored data
7. Estimation of mean survival time and variance of the estimator for type I and type II censored data
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data
9. To estimate the survival function and variance of the estimator using Non-parametric methods with Actuarial methods
10. To estimate Crude probability of death
11. To estimate Net-type I and Net-type II probability of death
12. To find the roots of a quadratic equations using Python
13. To calculate the first hundred prime numbers.
14. To calculate the factorial of a given number.
15. Matrix addition, subtraction and multiplication using Python
16. Random number generation using Python and obtain the value of pie using Monte-Carlo method.
17. Matrix addition, subtraction, multiplication Transpose and Trace.
18. Interpolation on Newton's forward, backward and divided differences interpolation formulae using Python.
19. Numerical Integration by Trapezoidal rule, Simpson's one-third rule, three-eight rule, Weddle's rule with error terms using Python.
20. Some Practical based on mathematical Analysis.

Semester-VII -(MJ-16)

Course Title: Stochastic Processes and Queuing Theory

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process.

UNIT II

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.

UNIT III

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

UNIT IV

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution in stationary cases only (without proof).

Suggested Readings:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

Semester-VII -(MJ-17)

Course Title: Multivariate Analysis

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.
Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

UNIT II

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance-covariance matrix (sans deduction). Multiple and partial correlation coefficient and their properties.

UNIT III

Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function.

UNIT IV

Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

Suggested Readings:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
5. Mukhopadhyay, P. :Mathematical Statistics.
6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.

Semester-VII -(MJ-18)

Course Title: Survey Sampling and Indian Official Statistics

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

UNIT II

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

UNIT III

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling

UNIT IV

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

Suggested Readings:

1. Cochran W.G. (1984):Sampling Techniques(3rd Ed.), Wiley Eastern.
2. Sukhatme,P.V., Sukhatme,B.V. Sukhatme,S. Asok,C.(1984). Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.

Semester-VII -(MJ-19)

Course Title: Operation Research

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

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.

UNIT II

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 III

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 of 2 X 2, rectangular game with mixed strategy.

UNIT IV

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

Suggested Readings:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice 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

Semester-VII-MJ (Practical-7)

Max. Marks: 100 ***Credit-4***

List of Practical

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of ergodic transition probability matrix
4. Stationarity of Markov chain and graphical representation of Markov chain
5. Computation of probabilities in case of generalizations of independent Bernoulli trials
6. Calculation of probabilities for given birth and death rates and vice versa
7. Calculation of probabilities for Birth and Death Process
8. Calculation of probabilities for Yule Furry Process
9. Computation of inter-arrival time for a Poisson process.
10. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
11. Calculation of generating function and expected duration for different amounts of stake.
12. Computation of probabilities and expected duration between players
13. Bivariate Normal Distribution,
14. Multivariate Normal Distribution
15. Test for randomness based on total number of runs,
16. Kolmogrov Smirnov test for one sample.
17. Sign test: one sample, two samples, and large samples.
18. Wilcoxon-Mann-Whitney U-test
19. Kruskal-Wallis test
20. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
21. Identifying Special cases by Graphical and Simplex method and interpretation

a. Degenerate solution **b**. unbounded solution **c**. Alternate solution **d**. infeasible solution

22. Allocation problem using Transportation model
23. Allocation problem using Assignment model
24. Problems based on game matrix
25. To find optimal inventory policy for EOQ model sand its variations

Semester-VIII -(MJ-20)

Course Title: Actuarial Statistics

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

UNIT II

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

UNIT III

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, timeuntil-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

UNIT IV

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

Suggested Readings:

1. Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.

Semester-VIII-MJ (Practical-8)

Max. Marks: 25 ***Credit-1***

List of Practical

1. Risk computation for different utility models
2. Discrete and continuous risk calculations
3. Calculation of aggregate claims for collective risks
4. Calculation of aggregate claim for individual risks
5. Computing Ruin probabilities and aggregate losses
6. Annuity and present value of contract
7. Computing premium for different insurance schemes
8. Practical based on life models and tables

Semester-VIII -(AMJ-1)

Course Title: Linear Models

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.

UNIT II

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models (Matrix and scalar versions) and estimation.

UNIT III

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

UNIT IV

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

Suggested Readings:

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.

Semester-VIII -(AMJ-2)

Course Title: Econometrics

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Introduction: Econometric models and its essences. General linear model (GLM) and its estimation. Simultaneous equation model: structural and reduced forms.

UNIT II

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, detection and remedies of multicollinearity, specification errors.

UNIT III

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and remedies of autocorrelation.

UNIT IV

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models.

Suggested Readings:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited,
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.

Semester-VIII -(AMJ-3)

Course Title: Data Analytics using Python

Max. Marks: 100 (Mid-Term:15, End-term: 60, Practical: 25)

UNIT I

Basics of Python Spyder (Tool)

1. Introduction Spyder 2. Setting working Directory 3. Creating and saving a script file

4. File execution, clearing console, removing variables from environment, clearing environment

5. Commenting script files 6. Variable creation 7. Arithmetic and logical operators

8. Data types and associated operations

UNIT II

Sequence data types and associated operations

1. Strings 2. Lists 3. Arrays 4. Tuples 5. Dictionary 6. Sets 7. Range 8. Numpy.ndarray

UNIT III

Pandas dataframe and dataframe related operations
(on India's Statistical Survey Data or UNDP data or any other dataset)

1. Reading files 2. Exploratory data analysis 3. Data preparation and preprocessing

Data visualization using matplotlib

1. Scatter plot 2. Line plot 3. Bar plot 4. Histogram 5. Box plot 6. Pair plot

Control structures of India's Population Dataset

1. if-else family 2. for loop 3. for loop with if break 4. while loop 5. Functions

UNIT IV

Case Study Regression

1. India's Statistical Survey Data on Population
2. Classifying personal income / GDPor any other similar dataset.

Suggested Readings:

1. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.".
2. Swaroop, C. H. (2003). A Byte of Python. Python Tutorial.
3. Ken Black, sixth Editing. Business Statistics for Contemporary Decision Making. "John Wiley & Sons, Inc".
4. Anderson Sweeney Williams (2011). Statistics for Business and Economics. "Cengage Learning".

Semester-VIII-AMJ (Practical)

Max. Marks: 75 ***Credit-3***

List of Practical

1. Estimability when X is a full rank matrix and not a full rank matrix
2. Distribution of Quadratic forms
3. Simple Linear Regression , Multiple Regression
4. Tests for Linear Hypothesis
5. Analysis of Variance of a one way classified data and two way classified data
6. Analysis of Covariance of a one way classified data and two way classified data
7. Problems based on estimation of General linear model
8. Testing of parameters of General linear model
9. Forecasting of General linear model
10. Problems concerning specification errors
11. Problems related to consequences of Multicollinearity
12. Problems related to consequences of Autocorrelation
13. Estimation of problems of General linear model under Autocorrelation
14. Problems related to consequences Heteroscedasticity
15. Estimation of problems of General linear model under Heteroscedastic distance terms
16. Problems related to General linear model under (Aitken Estimation)
17. Download the Python editor on the PC / Smartphoone & write & Run basic Programs.
18. Import the data file in the program & perform the given set of operations on the dataset.
19. Plot the dataset in various form: Scatter, Line, Bar Diagram, Pie Chart etc.
20. Fitting of dataset: Linear fit, non-linear fit., Normal distribution fit etc.
21. Data Modeling & Predictions from the given dataset.

Part – B
(Minor, MDC, and IAP Papers)

Semester-I - (MN-1A)

Course Title: Basic Statistics and Probability

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks: 25 ***Credit-1***

UNIT I

Concepts of a statistical population and sample from a population, quantitative and qualitative data, nominal, ordinal and time-series data, discrete and continuous data. Presentation of data by tables and by diagrams, frequency distributions for discrete and continuous data, graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods).

UNIT II

Measures of location (or central tendency) and dispersion, moments, measures of skewness and kurtosis, cumulants. Bivariate data: Scatter diagram, principle of least-square and fitting of polynomials and exponential curves.

UNIT III

Correlation and regression. Karl Pearson coefficient of correlation, Lines of regression, Spearman's rank correlation coefficient, multiple and partial correlations (for 3 variates only).

UNIT IV

Random experiment, sample point and sample space, event, algebra of events, Definition of Probability - classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorem on probability, conditional probability, independent events. Baye's theorem and its applications.

Note:Practical based on all the units in this course.

Suggested Reading:

1. A.M. Goon, M.K. Gupta and B. Dasgupta (2005): *Fundamentals of Statistics*, Vol. I, 8th Ed., World Press, Kolkatta.
2. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
3. R.V. Hogg, A.T. Craig and J.W. Mckean (2005): *Introduction to Mathematical Statistics*, 6th Ed., Pearson Education.
4. A.M. Mood, F.A. Graybill and D.C. Boes (2007): *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw Hill Publication.

Semester-I/II/III -(MDC1/2/3)

Course Title: Introduction to Statistics

Max. Marks: 75

UNIT I

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Scales of measurement -nominal, ordinal, interval and ratio. Variables and attributes, Diagrammatical Representation of Data, Summarization of Data: Frequency Distribution and Graphical Presentation.

UNIT II

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

UNIT III

Bi-variate data: Definition, scatter diagram, correlation, rank-correlation. Fitting of linear and quadratic regression using principle of least squares. Theory of attributes and consistency of data, independence and association of attributes, measures of association and contingency for 2x2 tables.

Suggested Reading:

1. S. C. Gupta, V. K. Kapoor, 12th Edition, (2017), Fundamental of Mathematical Statistics, Sultan Chand & Sons.
2. Miller, I. and Miller, M. (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. (2011). Introduction to the Theory of Statistics, 3rd Edn., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.

Semester-II -(MN-2A)

Course Title: Data Analysis using Spread sheet

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks: 25 ***Credit-1***

UNIT I

Graphical Representations-Role, historical perspective, terminology, types of classinterval-inclusive, exclusive, Formula to generate class intervals, types of graphs-Histogram,frequency curve, frequency polygon, pie chart, Ogive-more than and less than, Box plot,stem-leaf.

UNIT II

Measures of Central tendency-Arithmetic Mean, Harmonic Mean, Geometric Mean,Median and Mode explanation with example, Measures of Dispersion-Range, Semi InterquartileRange, Standard Deviation, Mean Deviation and explanation with example.

UNIT III

Curve Fitting - Principle of least squares Method, fitting of various curves likeStraight line, Second degree Polynomial, kth degree Polynomial and exponential curves,Plotting of various probability distribution like Binomial, Poisson, Normal Distribution withsuitable example.

UNIT IV

Introduction to Correlation Analysis, role, uses, its properties and formula,Introduction to Regression Analysis, role, uses, properties of its coefficient and formula tocalculate regression coefficient, Regression Line, explain with example.

Note:Practical based on all the units in this course.

Suggested Reading:

1. Artymiak, J. (2011). Beginning Open Office Calc: From Setting Up SimpleSpreadsheets to Business Forecasting. Apress Publisher.
2. Billo, E. J. (2007). Excel for Scientists and Engineers Numerical Methods. JohnWiley & Sons.
3. Carlberg, C. (2011). Statistical Analysis. Pearsons Education Inc.
4. Held, B. (2007). Microsoft Excel Functions and Formulas. Wordware Publishing, Inc.
5. Kanji, G.K. (2006). 100 Statistical Tests (3rd ed.). Sage Publication.
6. Remenyi, D., Onofrei, G. and English, J. (2011). An Introduction to Statistics usingMicrosoft Excel. Academic Publishing Limited.

Semester-III - (MN-1B)

Course Title: Statistical Methodology

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks: 25 ***Credit-1***

UNIT I

Random variables: Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations of random variables and its properties, expectation of random variable and its properties. Moments and cumulants, moment generating function, cumulants generating function and characteristic function.

UNIT II

Bivariate probability distributions, marginal and conditional distributions; independence of variates (only general idea to be given). Transformation in univariate and bivariate distributions.

UNIT III

Point (or degenerate), Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Normal, Uniform, Exponential, Beta and Gamma distributions.

UNIT IV

Markov inequality, Chebychev's inequality, WLLN and SLLN: Statements and applications, Central limit theorem (CLT) for i.i.d. variates, and its applications.

Note:Practical based on all the units in this course.

Suggested Reading:

1. A.M. Goon, M.K. Gupta and B. Dasgupta (2003): *An outline of Statistical Theory* (Vol. I), 4th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
3. R.V. Hogg, A.T. Craig, and J.W. Mckean (2005): *Introduction to MathematicalStatistics*, 6th Ed. Pearson Education.
4. A.M. Mood, F.A. Graybill and D.C. Boes (2007): *Introduction to the Theory ofStatistics*, 3rd Ed., Tata McGraw Hill Publication.
5. V.K. Rohtagi and A.K. Md. E. Saleh (2009): *An Introduction to Probablity andStatistics*, 2nd Edition, John Wiley and Sons.

Semester-IV-(MN-2B)

Course Title: Statistical Data Analysis Using R

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks: 25 ***Credit-1***

UNIT I

Data Loading, bar charts, pie charts, histograms (equal class intervals and unequal class intervals), frequency polygon, ogives, box plot, stem-leaf.

UNIT II

Generate automated reports giving detailed descriptive statistics, lines of regression and correlation.

UNIT III

Random number generation and sampling procedures. Fitting of polynomials and exponential curves. Application Problems based on fitting of suitable distribution, Normal probability plot.

UNIT IV

Simple analysis and create and manage statistical analysis projects, import data, code editing, Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals.

Note:Practical based on all the units in this course.

Suggested Reading:

1. Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
2. Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York 60

Semester-V - (MN-1C)

Course Title: Theory of Statistical Inference

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks: 25 ***Credit-1***

UNIT I

Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors, power of a test and critical region. Sampling distribution of a statistic, sampling distribution of sample mean, standard error of sample mean.

UNIT II

Large sample tests for single mean, difference of means, standard deviation and difference of standard deviations. Sampling distributions of chi-sq, t and F: definitions, properties and relationships between them. Tests of Significance based on Chi-square (goodness of fit and independence of attributes), t distribution and F- distribution using classical and p-value approach.

UNIT III

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators. Cramer-Rao inequality: statement and application, Methods of estimation: maximum likelihood, least squares and minimum variance, statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem. Properties of maximum likelihood estimators (illustration).

UNIT IV

Interval Estimation: confidence intervals for the parameters of normal distribution, confidence intervals for difference of mean and for ratio of variances. Neyman-Pearson lemma and MP test: statements and applications.

Note:Practical based on all the units in this course.

Suggested Reading:

1. A.M. Goon, M.K. Gupta and B. Dasgupta (2003): *An Outline of Statistical Theory* (Vol. I), 4th Ed., World Press, Kolkata.
2. S.C. Gupta and V.K. Kapoor (2007): *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons.
3. R.V. Hogg, A.T. Craig and J.W. Mckean (2005): *Introduction to MathematicalStatistics*, 6th Ed. Pearson Education.

Semester-VI-(MN-2C)

Course Title: Statistical Techniques for ResearchMethods

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks:25 ***Credit-1***

UNIT I

Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.

UNIT II

Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.

UNIT III

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

UNIT IV

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), interpret the results and draw inferences.

Note: Practical based on all the units in this course.

Suggested Reading:

1. Cochran, W.G. and Cox, G.M. (1959). Experimental Design. Asia Publishing House.

2. Kothari, C.R. (2015). Research Methodology: Methods and Techniques (3rd ed. reprint).New Age International Publishers.

3. Kumar, R. (2011). Research Methodology: A Step - by - Step Guide for Beginners.SAGE publications.

4. Project Work (using spread sheet and statistical packages –SPSS/R)

Semester-VII-(MN-1D)

Course Title: Survey Sampling and Design of Experiments

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks:25 ***Credit-1***

UNIT I

Sample Surveys: Basic concepts of sample survey: concept of sampling, need for sampling, complete enumeration v/s. sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors.Simple random sampling (srswr and srswor),Stratified random samplingSystematic sampling.

UNIT II

Analysis of variance: one-way and two-way classified data with one observation per cell only. Design of experiments: Principles of Design of experiments, uniformity trails, completely randomized, Randomized block and Latin square designs.

UNIT III

Missing plot technique: Analysis under a single missing observation: Missing plot technique for RBD and LSD. Factorial experiments: 2^2 and 2^3 Factorial experiments: construction and analysis.

UNIT IV

Indian Official Statistics: Present Official Statistical System in India relating to census of population, agriculture, industrial production, and prices; methods of collection of official statistics, major publications, their reliability and limitations. Agencies responsible for the data collection- C.S.O., N.S.S.O., Office of Registrar General: historical development, main functions and important publications.

Note:Practical based on all the units in this course.

Suggested Reading:

1. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
2. D.C. Montgomery (2001): *Designs and Analysis of Experiments*, John Wiley and Sons, New York.
3. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok (1984): *Sampling Theoryof Surveys with Applications*, Lowa State University Press, Lowa, USA.
4. Guide to current Indian Official Statistics, Central Statistical Office, GOI,New Delhi.
5. http://mospi.nic.in/

Semester-VIII-(MN-2D)

Course Title: Data Base Management Systems

Max. Marks: 75 (Mid-Term:15, End-term: 60) ***Credit-3***
Practical Marks:25 ***Credit-1***

UNIT I

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

UNIT II

Relational Database Management System: The Relational Model, Introduction to SQL: Basic Data Types, Working with relations of RDBMS: Creating relations e.g. Bank, College Database (create table statement)

UNIT III

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 IV

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.

Note: Practical based on all the units in this course.

Suggested Reading:

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