Department of Statistics

Kohima Science College, Jotsoma

(An Autonomous Government PG College)

Nagaland

Syllabus for Four Year Undergraduate Programme

NEP-2020

Subject: Statistics

2024

Semester –I

Major – 1: Title- Descriptive Statistics & Probability Theory (Theory)

Credit – 3 (75 Marks)

Unit-I: Statistical Methods: 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. Presentation: tabular and graphical, including histogram and ogives.

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations. Jacobian of transformation. (25 Marks)

Unit-II: Measures of Central Tendency: Definition and requisite characteristics, Arithmetic mean, Geometric mean and Harmonic mean; Median, Mode and their merits, demerits and properties; Quartiles, deciles and percentiles.

Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, Sheppard's corrections for moments; Skewness and kurtosis. (25 Marks)

Unit-III: 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. (25 Marks)

Major-1: Descriptive Statistics and Probability Theory (Practical)

Credit-1 (25 Marks)

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.

Recommended Books and References:

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.
4. V. K. Kapoor & S.C. Gupta: Fundamentals of Mathematical Statistics . sultan chand & co. New Delhi.
5. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
6. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
7. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.

Minor – 1: Title- Descriptive Statistics & Probability Theory (Theory) Credit-3 (75 Marks)

Unit-I: Statistical Methods: 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. Presentation: tabular and graphical, including histogram and ogives.

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations. Jacobian of transformation. (25 Marks)

Unit-II: Measures of Central Tendency: Definition and requisite characteristics, Arithmetic mean, Geometric mean and Harmonic mean; Median, Mode and their merits, demerits and properties; Quartiles, deciles and percentiles.

Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, Sheppard's corrections for moments; Skewness and kurtosis. (25 Marks)

Unit-III: 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. (25 Marks)

Minor-1: Descriptive Statistics and Probability Theory (Practical) Credit-1 (25 Marks)
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.

Recommended Books and References:

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.
4. V. K. Kapoor & S.C. Gupta: Fundamentals of Mathematical Statistics . sultan chand & co. New Delhi.
5. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
6. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
7. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.

MD – I: Title- Statistical Method (Theory) Credit – 2 (50 Marks)

Unit-I: Statistical Methods: 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. Presentation: tabular and graphical, including histogram and

ogives, consistency and independence of data with special reference to attributes.
Measures of Central Tendency: Definition and requisite characteristics, Arithmetic mean, geometric mean and harmonic mean; Median, Mode and their merits, demerits and properties; Quartiles, deciles and percentiles. (25 Marks)

Unit-II: 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.
Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, Sheppard's corrections for moments; Skewness and kurtosis. (25 Marks)

MD – I: Statistical Methods (Practical) Credit – 1 (25Marks)
List of Practical

1. Tabular and 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.

Recommended Books and References:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. V. K. Kapoor & S.C. Gupta: Fundamentals of Mathematical Statistics . sultan chand & co. New Delhi.
3. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
4. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.

SEC – I: MS-Excel and R (Theory) Credit-1 (25 Marks)

Unit I: **MS-Excel**: Learn how to load data, Diagrammatic Representation: Types of diagrams: Simple bar, sub-divided bar, multiple bars, deviation bar, pie diagram, box plot, stem and leaf charts, scatter plot, line graph. Graphic Representation of frequency distribution: histogram, frequency curve, ogive curves.

Mean, median, mode, correlation coefficient, variance, standard deviation, covariance, one sample t-test, two sample t-test, paired t-test, Z-test, Chi-square test, F-test, one way ANOVA, two-factor ANOVA. Random number generation.

R installation Procedure; Help, Demonstration, and Examples in R; Packages and Libraries in R; Command Line and Data Editor

Introduction to R Studio; Basic Operations in R; R as a Calculator with Scalars and Data Vectors: Addition, Subtraction, Multiplication & Division

Calculations with Data Vectors: Addition, Subtraction, Multiplication & Division; R as a Calculator with Scalars and Data Vectors: Power operations, Integer and Modulo divisions; Built in Functions and Assignments; Matrices

Matrix Operations – Row, Column & Other Operations; Matrix Operations – Access and Mathematical Operations; Matrix Operations – Mathematical and Other Operations; Logical Operators; Relational and Logical Operators

Missing Data Handling, Conditional Executions – If and If-Else, Conditional Executions – Nested if, else-if and if-else; Functions for Conditional Executions – switch and which commands

Loops – for loop; Loops – while and repeat; Functions; Sequences.

More Sequences and Other Operations; Sequences of Dates and Alphabets; Repeats; Sorting, Ordering and Mode; Lists

Operations on Lists; Vector Indexing; Factors; Factors – Class and Unclass; Strings – Display and Formatting: Print and Format Function

Strings – Display and Formatting: Print and Format with Concatenate; Paste Function; String Splitting; Manipulations with Strings and Alphabets

Strings – Display and Formatting: Substitution and Replacement of Strings; Data Frames; Data Frames: Creation and Operations; Data Frames: Combining and Merging

Data Handling: Importing and Reading CSV and Tabular Data Files; Importing and Reading EXCEL and other Data Files; Saving and Writing Data Files; Introduction to Statistical Functions: Introduction, Frequencies and Partition Values;

Graphics: Scatter Plot and Bar Plots; Sub-Divided Bar Plots and Pie Diagram, Histogram; Bivariate and Three-Dimensional Scatter Plots, Some Examples of R Programming.

(25 Marks)

SEC – I: MS-Excel and R (Practical): Credit-2 (50 Marks)

List of Practical

1. Diagrammatic Representation: Simple bar, sub-divided bar, multiple bars, deviation bar, pie diagram, box plot, stem and leaf charts, scatter plot, line graph. Graphic Representation of frequency distribution: histogram, frequency curve, ogive curves. (MS-Excel)
2. Mean, median, mode, correlation coefficient, variance, standard deviation, covariance, one sample t-test, two sample t-test, paired t-test, Z-test, Chi-square test, F-test, one way ANOVA, two-factor ANOVA. Random number generation. (MS-Excel)
3. Calculator with Scalars and Data Vectors: Addition, Subtraction, Multiplication & Division (R)
4. Matrix Operations (R)
5. Importing and Reading CSV and Tabular Data Files (R)
6. Graphics: Scatter Plot and Bar Plots; Sub-Divided Bar Plots and Pie Diagram, Histogram; Bivariate and Three-Dimensional Scatter Plots (R)

Recommended books and references:

1. Gardener M.: Beginning R: The Statistical Programming Language. Wiley Publications.
2. Verzani John (2014): Using R for Introductory Statistics. CRC Press, Taylor and Francis Group.
3. Pierre-Andre Cornillon et. al. (2015). R for Statistics. CRC Press, Taylor and Francis Group.

Semester –II

Major – 2: Title- Probability Distributions and Correlation Analysis (Theory)

Credit – 3 (75 Marks)

Unit-I: Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional Expectations. (25 Marks)

Unit-II: Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, Hypergeometric.

Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and Relationship. (25 Marks)

Unit-III: Correlation and regression: Definition, scatter diagram, product moment correlation coefficient and rank correlation coefficient. Method of least square and Curve fitting (fitting of polynomials and exponential curves). Regression analysis: line of regression, regression coefficients and their properties.

Multiple and partial correlation (3 variables only). Properties of residual. Plane of regression. Intraclass correlation and correlation ratio. (25 Marks)

Major-2: Probability Distributions and Correlation Analysis (Practical)

Credit 1 (25 Marks)

List of Practical

1. Fitting of binomial distributions for n and p = q = ½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on negative binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.
16. Fitting of polynomials, exponential curves.
17. Karl Pearson correlation coefficient.
18. Correlation coefficient for a bivariate frequency distribution.
19. Lines of regression, angle between lines and estimated values of variables.
20. Spearman rank correlation with and without ties.
21. Partial and multiple correlations.
22. Planes of regression and variances of residuals for given simple correlations.

Recommended Books and References:

1. S.C. Gupta & V.K.Kapoor(2015) : Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi.
2. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
3. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
4. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

6. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

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

Minor – 2: Title- Probability Distributions and Correlation Analysis (Theory)

Credit-3 (75 Marks)

Unit-I: Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional Expectations. (25 Marks)

Unit-II: Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, Hypergeometric.

Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and Relationship. (25 Marks)

Unit-III: Correlation and regression: Definition, scatter diagram, product moment correlation coefficient and rank correlation coefficient. Method of least square and Curve fitting (fitting of polynomials and exponential curves). Regression analysis: line of regression, regression coefficients and their properties.

Multiple and partial correlation (3 variables only). Properties of residual. Plane of regression. Intraclass correlation and correlation ratio. (25 Marks)

Minor-2: Probability Distributions and Correlation Analysis (Practical)

Credit 1 (25 Marks)

List of Practical

1. Fitting of binomial distributions for n and p = q = ½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
3. Fitting of Poisson distributions for given value of lambda.
4. Fitting of Poisson distributions after computing mean.
5. Fitting of negative binomial.
6. Fitting of suitable distribution.
7. Application problems based on binomial distribution.
8. Application problems based on Poisson distribution.

9. Application problems based on negative binomial distribution.
10. Problems based on area property of normal distribution.
11. To find the ordinate for a given area for normal distribution.
12. Application based problems using normal distribution.
13. Fitting of normal distribution when parameters are given.
14. Fitting of normal distribution when parameters are not given.
15. Fitting of polynomials, exponential curves.
16. Karl Pearson correlation coefficient.
17. Correlation coefficient for a bivariate frequency distribution.
18. Lines of regression, angle between lines and estimated values of variables.
19. Spearman rank correlation with and without ties.
20. Partial and multiple correlations.
21. Planes of regression and variances of residuals for given simple correlations.

Recommended Books and References:

1. S.C. Gupta & V.K.Kapoor(2015) : Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi.
2. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
3. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
4. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
6. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
7. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.

MD - II: Testing of Hypothesis (Theory) Credit – 2 (50 Marks)

Unit I: 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 (simple and composite), Type – I and Type – II errors, their probabilities and critical region, level of significance and p-value.

Large sample tests for testing single proportion, difference of two proportions, single mean, difference of two means and standard deviation by classical and p-value approaches.

t-test, F-test and χ^2- test. Tests of significance and confidence intervals based on distribution.

(25 Marks)

Unit II: **Nonparametric Tests:** Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

(25 Marks)

MD – II: Testing of Hypothesis (Practical) Credit – 1 (25 Marks)

List of Practical

1. Practical based on Z-test, t-test, F-test and χ^2- test
2. Practical based on Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

Recommended Books and References:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. V. K. Kapoor & S.C. Gupta: Fundamentals of Mathematical Statistics . sultan Chand & co. New Delhi.
3. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
4. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.

SEC – 2: Statistical Data Analysis Using Software Packages (SPSS) (Theory)

Credit-1 (25 Marks)

Unit I: Introduction: Data Entry, Storing and Retrieving Files, Generating New Variables; Managing Data: Listing Cases, Replacing Missing Values, Computing New Variables, Recoding Variables, Selecting Cases, Sorting Cases, Merging Files, Graphs – Creating and Editing Graphs

and Charts; Descriptive Statistics Procedures: Frequencies, Descriptive, Explore, Cross Tabulation.

Hypothesis Testing for Means: t-tests: One Sample Test, Independent Sample, Two Sample and Paired Sample t-test; ANOVA: One Way Analysis of Variance With Post Hoc Analysis, Two-way analysis of variance.

Chi-square Test of Independence; Bivariate Correlation Analysis: Simple Scatter Plot; Correlation Coefficient: Pearson, Spearman Rho, and Kendall Tau Coefficient; Factor Analysis. Principal Component Analysis.

Regression: Linear Regression: Simple Linear Regression, Multiple Linear Regression Analysis with Matrix Scatterplot; Multiple Regression: Standard (Enter) And Stepwise Method; Binary Logistic Regression.

SEC – 2: Statistical Data Analysis Using Software Packages (SPSS) (Practical)
Credit-2 (50 Marks)

List of Practical:

1. Data Entry, Storing and Retrieving Files, Generating New Variables; Managing Data: Listing Cases, Replacing Missing Values, Computing New Variables, Recoding Variables, Selecting Cases, Sorting Cases, Merging Files, Graphs – Creating and Editing Graphs and Charts; Descriptive Statistics Procedures: Frequencies, Descriptive, Explore, Cross Tabulation.

2. One Sample Test, Independent Sample, Two Sample and Paired Sample t-test; ANOVA: One Way Analysis of Variance With Post Hoc Analysis, Two-way analysis of variance.

3. Chi-square Test of Independence; Bivariate Correlation Analysis: Simple Scatter Plot; Correlation Coefficient: Pearson, Spearman Rho, and Kendall Tau Coefficient; Factor Analysis. Principal Component Analysis.

4. Linear Regression: Simple Linear Regression, Multiple Linear Regression Analysis with Matrix Scatterplot; Multiple Regression: Standard (Enter) And Stepwise Method; Binary Logistic Regression.

Recommended Books and References:

1. Cunningham, B.J (2012):Using SPSS: An Interactive Hands-on approach.
2. George A. Morgan, Nancy L. Leech, Gene W. Gloeckner, Karen C. Barrett: SPSS for Introductory Statistics: Use and Interpretation, LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
3. Lalit Prasad and Priyanka Mishra. DATA ANALYSIS USING SPSS: Text and Cases, For Researchers, Teachers and Students. Nirali Prakashan (1 January 2022); Nirali Prakashan
4. D.N. Sansanwal. DATA ANALYSIS USING SPSS. Shipra Publications (1 January 2023).

VAC – 2: Indian Knowledge System (IKS): Indian Culture and Civilization

Credit – 3 (75 Marks)

Unit I: Introduction to IKS:

Caturdaśa Vidyāsthānam, 64 Kalas**,** Shilpa Śāstra, Four Vedas, Vedāṅga, Indian Philosophical Systems, Vedic Schools of Philosophy (Sāṃkhya and Yoga, Nyaya and Vaiśeṣika, Pūrva-Mīmāṃsā and Vedānta), Non-Vedic schools of Philosophical Systems (Cārvāka, Buddhist, Jain), Puranas (Maha-puranas, Upa-Puranas and Sthala-Puranas), Itihasa (Ramayana, Mahabharata), Niti Sastras, Subhasitas.

Humanities & Social Sciences in IKS: Health, Wellness & Psychology, Ayurveda Sleep and Food, Role of water in wellbeing Yoga way of life Indian approach to Psychology, the Triguṇa System Body-Mind-Intellect-Consciousness Complex. Governance, Public Administration & Management reference to ramayana, Artha Sastra, Kauṭilyan State. (25 Marks)

Unit II: Foundation concept for Science & Technology:

Linguistics & Phonetics in Sanskrit (panini's), Computational concepts in Astadhyayi Importance of Verbs, Role of Sanskrit in Natural Language Processing, Number System and Units of Measurement, concept of zero and its importance, Large numbers & their representation, Place Value of Numerals, Decimal System, Measurements for time, distance and weight, Unique approaches to represent numbers (Bhūta Saṃkhya System, Kaṭapayādi System), Pingala and the Binary system, Knowledge Pyramid, Prameya – A Vaiśeṣikan approach to physical reality, constituents of the physical reality, Pramāṇa, Saṃśaya.

Indian S & T Heritage ,sixty-four art forms and occupational skills (64 Kalas) Metals and Metalworking technology (Copper, Gold, Zinc, Mercury, Lead and Silver), Iron & Steel, Dyes and Painting Technology. (25 Marks)

Unit III: Indian Mathematics & Astronomy in IKS:

Indian Mathematics, Great Mathematicians and their contributions, Arithmetic Operations, Geometry (Sulba Sutras, Aryabhatiya-bhasya), value of π, Trigonometry, Algebra, Chandah Sastra of Pingala, Indian Astronomy, celestial coordinate system, Elements of the Indian Calendar Aryabhatiya and the Siddhantic Tradition Pancanga – The Indian Calendar System Astronomical Instruments (Yantras) Jantar Mantar or Raja Jai Singh Sawal. (25 Marks)

Suggested Readings:

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru.
2. Kapur K and Singh A. K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust, Bombay, 1995.
3. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.
4. SK Das, The education system of Ancient hindus, Gyan publication house, India

5. BL Gupta,Value and distribution system in india, Gyan publication house, India
6. Reshmi ramdhoni, Ancient Indian Culture and Civilisation, star publication ,2018
7. Supriya Lakshmi Mishra, Culture and History of Ancient India (With Special Reference of Sudras), 2020.
8. Gambirananda, Swami, Tr. Upanishads with the Commentary of Sankarachrya. Kolkata: Advaita Ashrama publication Department, 2002.
9. Ranganathananda, Swami. The Massage of the Upanishads. Bombay: Bharathya Vidya Bhaven, 1985.
10. Om Prakash, Religion and Society in Ancient India, Bhariya Vidhya Prakashan, 1985
11. J Auboyer, Daily Life in Ancient India from Approximately 200 BC to AD 700, Munshi ram Manoharlal publication, 1994.
12. DK Chakkrabarty, Makkhan Lal, History of Ancient India (Set of 5 Volumes), Aryan book Internation publication, 2014
13. Dr. Girish Nath Jha, Dr. Umesh Kumar Singh and Diwakar Mishra, Science and Technology in Ancient Indian Texts, DK Print World limited,
14. Swami BB Vishnu, Vedic Science and History - Ancient Indian's Contribution to the Modern World, gosai publication, 2015
15. Chatterjee, S.C. The Nyaya Theory of Knowledge. Calcutta: University of Calcutta Press, 1950.
16. Dasgupta, Surendra. A History of Indian Philosophy. Delhi: Motilal Banarsidass, 1991.Vols. III & IV.
17. Mercier, Jean L. From the Upanishads to Aurobindo. Bangalore: Asian Trading Corporation, 2001.
18. M. Hiriyanna. Essentials of Indian Philosophy. London: Diane Publications, 1985.
19. Hume, Robert Ernest, Tr. The Thirteen Principal Upanishads. Virginia: Oxford University Press, 1931.
20. Radhakrishnan, S. Principal Upanishads. New York: Harper Collins, 1963.
21. Satprakashananda. The Methods of Knowledge according to Advaita Vedanta. Calcutta: Advaita Ashram, 2005.
22. Potter, K.H. Encyclopaedia of Indian Philosophies, Vol.III. Delhi: Motilal Banarasidass, 2000.

OR

VAC – 2: Healthcare Systems and Policies

Credit – 3 (75 Marks)

Unit I: Basic Concepts: Concepts of Health; Public health; Community health; Preventive and curate health, Health promotion; Health services; and Primary, secondary and tertiary care.
Health System: Goals, boundaries, functions, and WHO's health system building blocks: service delivery, health workforce, health Information systems, access to essential medicines, financing and leadership/ governance.

Health Services: Basic models and functions of health services, international experiences and goals and elements in universal health care (UHC) approach. (25 Marks)

Unit II: Health care system in India: public sector, private sector, voluntary sector, human resources for health, access to health care, utilisation and expenditure on health services, and UHC initiatives and challenges ahead, SWOT analysis of Indian health system, a critique on the health delivery system- problems related to structural
Health policy: Concepts and tools of health policy, health policy stakeholders, health policy triangle framework, rational decision making to approach to health policymaking,
introduction to health policy and systems research. (25 Marks)

Unit III: Health policymaking in India: Health planning in post-Independent India, Bhore Committee Report 1946, National health policies, National Health Policy 2017, and current national health programmes.
Regulation in the health sector: Need for regulations, mechanisms for regulation, key legislations and standards in the health sector in India, and challenges in the implementation of regulations.
Health care legislations in India: Legal aspect of health care, MTP Act, biomedical waste Rules, COPRA Act, PNDT Act, Transplantation of human organs Act, etc. (25 Marks)

Suggested Readings:

1. Lassey M, Lassey W, and Jinks, M. (1997). Health Care Systems around the World: Characteristics, Issues and Reforms. Prentice-Hall, Inc.
2. Bodenheimer, Thomas S., Kevin Grumbach. Understanding Health Policy 3. Fort, Meredith, Mary Anne Mercer and Oscar Gish (Editors). Sickness and Wealth: The Corporate Assault on Global Health
4. Govt. of India (2017) - National Health Policy-2017, Ministry of Health and Family Welfare, New Delhi.
5. Peters, et.al (2002), Better Health System for India's poor. Findings, Analysis and Options: The World bank, New Delhi
6. Abel-Smith, Brian. An introduction to health: policy, planning and financing. Routledge, 2018.
Murray, Christopher JL, and Julio Frenk. "A framework for assessing the performance of healthsystems." Bulletin of the World Health Organization 78 (2000): 717-731.
6. Bhore, J. (1946). Report of the health survey and development committee (Vol. 1-4). Manager of Publications.
7. Reddy, K.S. et.al (2011)" Towards achievement of universal health care in India by 2020: A Call of Action", www.thelancet.com
8. Banerjee, D. (1982), Poverty, class and Health Culture in India, Vol. 1 Parchi Prakashan, New Delhi.
9. Indian Council of Social Science Research and Indian Council of Medical Research (1981), Health for All by 2000 A. D., ICSSR, Delhi.

10. Madan, T.N. (1969), "Who Chooses Modern Medicine and Why", Economic and Political Weekly, pp. 1475-84.
11. K. Sujatha Rao, (2017), Do We Care: India's Health System, Oxford University Press, 6 ISBN10: 9780199469543, 478 pages

Semester –III

Major-3: Title- Statistical Inference (Theory) Credit-3 (75 Marks)

Unit-I: Estimation: Concepts of estimator and estimate, criterion of a good estimator: consistency, unbiasedness, efficiency and sufficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE).
Methods of Estimation: Method of maximum likelihood estimation, method of moments, method of minimum Chi-square, basic idea of Bayes' estimators. (25 Marks)

Unit-II: 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).
Cramer-Rao inequality and MVB estimators (statement and applications), Rao-Blackwell theorem. Interval estimation- confidence interva1 and confidence limits. (25 Marks)

Unit-III: 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 (simple and composite), Type – I and Type – II errors, their probabilities and critical region, level of significance and p-value, power of a test.Best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof). Likelihood ratio (LR) test- tests for mean and variance of one, and two independent normal populations. Sequential Analysis: Wald's Sequential probability ratio test (SPRT). Fundamental relations among α, β, A and B. Five points of Operating characteristics (OC) and average sample number (ASN) functions.

(25 Marks)

Major-3: Title- Statistical Inference (Practical) Credit – 1 (25 Marks)

List of Practical

1. Unbiased estimators (including unbiased but absurd estimators).

2. Consistent estimators, efficient estimators and relative efficiency of estimator.
3. Cramer-Rao inequality and MVB estimators.
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators.
5. Lehman-Scheffe theorem and UMVUE.
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region
12. Unbiased critical region
13. Power curves
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
16. Asymptotic properties of LR tests

Recommended Books and References:

1. S.C. Gupta, V.K. Kapoor. Fundamentals of Mathematical Statistics. Sultan Chand and Co., New Delhi
2. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
3. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
4. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
5. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
6. Mood A.M, Graybill F.A. and Boes D.C,: Introduction to the Theory of Statistics, McGraw Hill.
7. 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.

Major – 4: Calculus (Theory)

Credit-4 (100 Marks)

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.

(25 Marks)

Unit II: Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems.
Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double and multiple integral, change of order of integration, transformation of variables.

(25 Marks)

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, Different forms of particular integrals, Linear differential equations with non-constant coefficients. (25 Marks)

Unit IV: Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non-homogeneous partial differential equations with constant coefficients. Classification of second order linear partial differential equations.

(25 Marks)

Recommended books and references:

1. Sudhir K. Pundir (2015). Mathematical Analysis. C.B.S. Publishers and Distributor, Ansari Road, New Delhi -110002.
2. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
3. Gorakh Prasad: Integral Calculus, PothishalaPvt. Ltd., Allahabad (14th Edition -2000).
4. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2nd Edition -2004).
5. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

Ravendra Kumar: Ordinary and Partial Differential Equations, Mahaveer Publication, Graham Bazar, Dibrugarh-786001

Minor-3: Title- Statistical Inference (Theory) **Credit-3 (75 Marks)**

Unit-I: Estimation: Concepts of estimator and estimate, criterion of a good estimator: consistency, unbiasedness, efficiency and sufficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE).
Methods of Estimation: Method of maximum likelihood estimation, method of moments, method of minimum Chi-square, basic idea of Bayes' estimators. (25 Marks)

Unit-II: 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).
Cramer-Rao inequality and MVB estimators (statement and applications), Rao-Blackwell theorem. Interval estimation- confidence interva1 and confidence limits. (25 Marks)

Unit-III: 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 (simple and composite), Type – I and Type – II errors, their probabilities and critical region, level of significance and p-value, power of a test. Best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof). (25 Marks)

Minor-3: Title- Statistical Inference (Practical) **Credit-1 (25 Marks)**

List of Practical

1. Unbiased estimators (including unbiased but absurd estimators).
2. Consistent estimators, efficient estimators and relative efficiency of estimator.
3. Cramer-Rao inequality and MVB estimators.
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators.
5. Lehman-Scheffe theorem and UMVUE.
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region

12. Unbiased critical region
13. Power curves
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis

Recommended Books and References:

1. S.C. Gupta, V.K. Kapoor. Fundamentals of Mathematical Statistics. Sultan Chand and Co., New Delhi
2. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
3. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
4. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
5. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
6. Mood A.M, Graybill F.A. and Boes D.C,: Introduction to the Theory of Statistics, McGraw Hill.
7. 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.

MD -III: Applied Statistics Credit – 3 (75 Marks)

Unit I: Statistical Quality Control: concepts**,** chance and assignable Causes of variation; Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, σ -chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart. (25 Marks)

Unit II: Educational and Psychological Statistics: Scaling of individuals for items in terms of difficulty, Z-score, standard score normalized scores, t-score and percentile score; Scaling of ratings in terms of normal probability curve; Test theory , Methods of estimating test reliability; Effect of test length on reliability of a test, validity of test scores, Intelligent quotient and its construction. (25 Marks)

Unit III: 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.

(25 Marks)

IN-III: Applied Statistics (Practical) Credit-1 (25 Marks)

List of Practical:

1. Construction and interpretation of statistical control charts X-bar & R-chart
2. X-bar & s-chart np-chart p-chart c-chart u-chart .
3. Calculation of Z-Score.
4. Calculation of T-Score.
5. Calculation of percentile score.
6. To select an SRS with and without replacement.
7. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
8. For SRSWOR, estimate mean, standard error, the sample size

SEC – 3: Statistical Computing Using C/C++ Programming (Theory)

Credit-1 (25 Marks)

Unit I: Overview of C: Basic structure of a C-program, Execution of C Program.

C Programming Basic Concepts: Character set, C token, Keywords and identifiers, Constants, Variables, data types, Declaration of variables, assigning values to variables, defining symbolic constants.

Input and output with C: Formatted I/O functions - printf and scanf, control stings and escape sequences, output specifications with printf functions; Unformatted I/O functions to read and display single character and a string - getchar, putchar, gets and puts functions.

Operators & Expressions**:** Arithmetic operators; Relational operators; Logical operators; Assignment operators; Increment & Decrement operators; Bitwise operators; Conditional operator; Special operators; Operator Precedence and Associatively; Evaluation of arithmetic expressions; Type conversion.

Control Structures: Decision Making and Branching -Decision making with if statement, simple if statement, the if else statement, nesting of if … else statements, the else if ladder, the switch statement, the go to statement. Decision making and looping - The while statement, the do statement, for statement, nested loops, exit, break, jumps in loops.

Derived data types in C: Arrays - declaration, initialization and access of one-dimensional and two-dimensional arrays. programs using one- and two-dimensional arrays, sorting and searching arrays.

Handling of Strings: Declaring and initializing string variables, reading strings from terminal, writing strings to screen, Arithmetic operations on characters, String handling functions - strlen, strcmp, strcpy, strstr and strcat; Character handling functions - toascii, toupper, tolower, isalpha, isnumeric etc.

Pointers: Understanding pointers, accessing the address of a variable, declaring and initializing pointers, accessing a variable through its pointer, pointer expression, pointer increments and scale factor, pointers and arrays, pointer and strings.

User-defined functions: Need for user-defined functions, Declaring, defining and calling C functions, return values and their types, Categories of functions: With/without arguments, with/without return values. Nesting of functions.

File Handling: Read and write to a file.

Structures and unions: Structure definition, giving values to members, structure initialization, comparison of structure variables, arrays of structures, arrays within structures, Structure and functions, structures within structures. Unions. (25 Marks)

SEC – 3: Statistical Computing Using C/C++ Programming (Practical)

Credit – 2 (50 Marks)

List of Practical

1. Plot of a graph y = f(x)
2. Roots of a quadratic equation (with imaginary roots also)
3. Sorting of an array and hence finding median
4. Mean, Median and Mode of a Grouped Frequency Data
5. Variance and coefficient of variation of a Grouped Frequency Data
6. Preparing a frequency table
7. Value of n! using recursion
8. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution, calculate sample mean and variance and compare with population parameters.
9. Matrix addition, subtraction, multiplication Transpose and Trace
10. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit
11. Chi-square contingency table
12. t-test for difference of means
13. Paired t-test
14. F-ratio test
15. Multiple and Partial correlation.
16. Compute ranks and then calculate rank correlation (without tied ranks)
17. Fitting of lines of regression

Recommended books and references:

1. E. Balagurusamy, Programming in ANSI C, 7th Edition, Tata McGraw Hill
2. Herbert Schildt, C: The Complete Reference, 4th Edition
3. Brain W. Kernighan, C Programming Language, 2nd Edition, Prentice Hall Software
4. Kernighan & Ritchie: The C Programming Language, 2nd Edition, PHI
5. 6. V. Rajaraman, Computer Programming in C, 2nd Edition, PHI
7. S. Byron Gottfried, Programming with C, 2nd Edition, TMH
8. Yashwant Kanitkar, Let us C, 15th Edition, BPB
9. T. Jeyapoovan. A First Course In Programming With C. S Chand; First Edition (2004).

Semester –IV

Major – 5: Sampling Distributions, Order Statistics Non-Parametric Tests and, Theory of Attributes (Theory) Credit-3 (75 Marks)

Unit I: Exact sampling distribution I: 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 χ^2 distribution. Exact sampling distribution II: Student's and Fishers 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 χ^2 distributions. Test of significance and confidence Intervals based on t and F distributions.

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. (25 Marks)

Unit II: Large sample tests 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.

Applications of t-test, F-test and χ^2- test. Tests of significance and confidence intervals based on distribution. (25 Marks)

Unit III: Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

Theory of attributes: Introduction, class and class frequencies, consistency of data, independence of attributes, association of attributes, Yule's coefficient of association, coefficient of colligation. (25 Marks)

Major – 5: Sampling Distributions, Non-Parametric, Theory of Attributes and Order Statistics (Practical) **Credit-1 (25 Marks)**

List of Practical:

1. Practical based on t-test, F-test and χ^2- test
2. Testing of significance and confidence intervals for single proportion and difference of two proportions
3. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
4. Testing of significance and confidence intervals for difference of two standard deviations.
5. Exact Sample Tests based on Chi-Square Distribution.
6. Testing if the population variance has a specific value and its confidence intervals.
7. Testing of significance and confidence intervals of an observed sample correlation coefficient.
8. Testing and confidence intervals of equality of two population variances
9. Test for randomness based on total number of runs,
10. Kolmogrov Smirnov test for one sample.
11. Sign test: one sample, two samples, large samples.
12. Wilcoxon-Mann-Whitney U-test
13. Kruskal-Wallis test

Recommended books and 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. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
3. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
4. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Co.
6. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
7. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
8. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4th Edn. John Wiley and Sons.
9. 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.
10. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Co.

Major – 6: Survey Sampling (Theory) Credit-3 (75 Marks)

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.

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, post stratification and its performance. (25 Marks)

Unit II: Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=n×k). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Introduction to Ratio and regression methods of estimation, first approximation to the population means 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. (25 Marks)

Unit III: 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.

Two stage and multistage sampling, two phase and multi-phase sampling (concept only); PPS Sampling, estimation of population total, mean and variance. (25 Marks)

Major – 6: Survey Sampling (Practical) Credit-1 (25 Marks)

List of Practical:

1. To select an SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods
5. Compare the efficiencies of above two methods relative to SRS
6. Estimation of gain in precision in stratified sampling.

7. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
8. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.

Recommended books and references:

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
2. Daroga Singh & F. S. Choudhury: Theory and Sample Survey Designs. Wiley Eastern Limited.
3. Choudhury, Sarma, Deka, Gogoi. An Introduction to Statistics.
4. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
5. Sukhatme,P.V., Sukhatme, B.V. Sukhatme,S. Ashok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
6. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
7. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
8. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.

Major-7: Algebra (Theory) **Credit-4 (100 Marks)**

Unit I: Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients of any polynomial equation. 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.

(25 Marks)

Unit II: Algebra of matrices - A review, theorems related to triangular, idempotent, involutory and nilpotent matrices, symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices and orthogonal matrices. Trace of a matrix, transpose of a matrix, Unitary, adjoint and inverse of a matrix and related properties. 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. Solutions of linear homogenous and non homogenous equation. (25 Marks)

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. 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.

(25 Marks)

Unit IV: Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms.

(25 Marks)

Recommended books and references:

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. Artin M.: Algebra. Prentice Hall of India, 1994.
8. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint), 2002.
10. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley &Sons., 1982

Major-8: Applied Statistics (Theory) **Credit-3 (75 Marks)**

Unit I: Quality: Definition, dimensions of quality. Statistical Quality Control: concepts**,** Statistical Process Control - Seven tools of SPC, Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, σ -chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability. (25 Marks)

Unit II: 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. Cost of living (Consumer price) index number, problems in the construction of consumer price index number and its uses; Wholesale price index number. Index of Industrial Production, agricultural production. (25 Marks)

Unit III: Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Types of data required for estimating elasticity: family budget data and time series data; Pareto's law of income distribution; Engel's law and Engel's curve; Lorentz curve.

Educational and Psychological Statistics: Scaling of individuals for items in terms of difficulty, Z-score, standard score normalized scores, T-score and percentile score; Scaling of ratings in terms of normal probability curve; Test theory, Methods of estimating test reliability; Effect of test length on reliability of a test, validity of test scores, Intelligent quotient and its construction.

(25 Marks)

Major-8: Applied Statistics (Practical) Credit-1 (25 Marks)

List of Practical:

1. Construction and interpretation of statistical control charts X-bar & R-chart

   X-bar & s-chart np-chart p-chart c-chart u-chart

2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. SPRT procedure :OC function and OC curve, ASN function and ASN curve
4. Calculate price and quantity index numbers using simple and weighted average of price relatives.
5. To calculate the Chain Base and consumer price index numbers.
6. Fitting of demand curve.
7. Fitting of Pareto's curve.
8. Calculation of Z-Score.
9. Calculation of T-Score.
10. Calculation of percentile score.

Recommended Books and References:

1. Fundamentals of Statistics. S.C. Gupta, Sultan Chand and Co.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
4. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road,

New Delhi -110002.
5. Parimal Mukhopadhyay. Applied Statistics, Books & Allied Ltd.
6.Veer Bala Rastogi. Biostatistics, Medtech; 3rd edition (6 July 2015)

Minor – 4: Sampling Distributions, Non-Parametric, Theory Of Attributes And Order Statistics (Theory) Credit-3 (75 Marks)

Unit I: Exact sampling distribution I: 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 χ^2 distribution. Exact sampling distribution II: Student's and Fishers 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 χ^2 distributions. Test of significance and confidence Intervals based on t and F distributions.
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. (25 Marks)

Unit II: Large sample tests 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.
Applications of t-test, F-test and χ^2- test. Tests of significance and confidence intervals based on distribution. (25 Marks)

Unit III: Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.
Theory of attributes: Introduction, class and class frequencies, consistency of data, independence of attributes, association of attributes, Yule's coefficient of association, coefficient of colligation. (25 Marks)

Minor – 4: Sampling Distributions, Non-Parametric, Theory Of Attributes And Order Statistics (Practical) Credit-1 (25 Marks)
List of Practical:

1. Practical based on t-test, F-test and χ^2- test
2. Testing of significance and confidence intervals for single proportion and difference of twoproportions
3. Testing of significance and confidence intervals for single mean and difference of two meansand paired tests.

4. Testing of significance and confidence intervals for difference of two standard deviations.
5. Exact Sample Tests based on Chi-Square Distribution.
6. Testing if the population variance has a specific value and its confidence intervals.
7. Testing of significance and confidence intervals of an observed sample correlation coefficient.
8. Testing and confidence intervals of equality of two population variances
9. Test for randomness based on total number of runs,
10. Kolmogrov Smirnov test for one sample.
11. Sign test: one sample, two samples, large samples.
12. Wilcoxon-Mann-Whitney U-test
13. Kruskal-Wallis test

Recommended books and 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. Barman, Hazarika & Bora (2021). Statistical Methods. Mahaveer Publications, Dibrugarh – 786001
3. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
4. Mohanty & Biswal (2022). Probability and Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Co.
6. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
7. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
8. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics- Principles and Methods*, 4th Edn. John Wiley and Sons.
9. 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.
10. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand and Co.

Semester –V

Major-9: Linear Models and ANOVA (Theory)

Credit-3 (75 Marks)

Unit I: Gauss- Markov set- up: Theory of linear estimation, Estimability of linear parameter functions. Method of least squares, Gauss- Markov theorem, Estimation of error variance.
Regression analysis: Test for the relationship between two variables, linearity of regression, test for polynomial regression, test for multiple linear regression model, test for the homogeneity of a group of regression coefficients. (25 Marks)

Unit II: Analysis of variance (ANOVA): Introduction and assumptions. Definitions of fixed, random and mixed effect models, analysis of variance in one-way and two-way classified data with one and two observations per cell for fixed effect model. (25 Marks)

Unit III: Analysis of Covariance (ANCOVA): Introduction, layout, statistical analysis and computational short cuts for one way and two-way classified data with single observation per cell. (25 Marks)

Major-9: Linear Models and ANOVA(Practical) Credit-1 (25 Marks)

List of Practicals:

1. Analysis of Variance of a one way classified data
2. Analysis of Variance of a two way classified data with one observation per cell
3. Analysis of Covariance of a one way classified data
4. Analysis of Covariance of a two way classified data

Recommended Books and References:

1. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.

Major-10: Time Series Analysis (Theory) Credit-3 (75 Marks)

Unit I: Introduction to times series data, application of time series from various fields, components of times series, Decomposition of time series. 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. Seasonal Component: Estimation of seasonal component by Method of Simple averages, Ratio of Trend, Ratio to moving Averages and Link Relative method, Deseasonalisation. (25 Marks)

Unit II: Cyclic Component: Harmonic Analysis. Multicolinearity: Nature, Estimation of parameters and detection of multicolinearity. Random component: Variate component method. Forcasting: Exponential smoothing methods, Short term forcasting methods: Brown's discounted regression, Box- Jenkins method and Bayesian forecasting. (25 Marks)

Unit III: Autocorrelation: Autocorrelation function and correlogram, Stationary Time series: Weak stationary. Autoregression: Moving average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2)- Yule walker equations. (25 Marks)

Major-10: Time Series Analysis (Practical) Credit-1 (25 Marks)

List of Practical

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Calculation of variance of random component by variate difference method
9. Forecasting by exponential smoothing
10. Forecasting by short term forecasting methods.

Recommended Books and References:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
4. Damodar N. Gujarati. Basic Econometrics. Mc. Graw Hill International.

Major 11: Demography (Theory) Credit-3 (75 Marks)

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

Migration: definition and kind of migration, estimation of migration rates, components of Migration.

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 Standardised Death Rates. Stationary and Stable population, Central Mortality Rates and Force of Mortality. (25 Marks)

Unit II: Life (Mortality) Tables: Assumption, description, construction of Life Tables and uses of Life Tables. Double and multiple decrement life table, indirect estimation of life expectancy, model life tables. Abridged Life Tables: Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. 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). (25 Marks)

Unit III: 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. Indian agricultural statistics, Industrial statistics. Concept of National Accounts Statistics (GDP, NDP, GNP and NNP). (25 Marks)

Major 11: Demography (Practical) Credit-1 (25 Marks)

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 fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them
9. To calculate the probability of dying from a particular cause of death (multiple decrement life table).

Recommended Books and References

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
2. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
4. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
6. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.
7. Bhende A.A. Kanitkar Tara: Principles of Population Studies ,Himalayan Publishing House, Mumbai-400004.

Minor – 5: Survey Sampling and Design of Experiment (Theory)

Credit-3 (75 Marks)

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. Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=n×k).

(25 Marks)

Unit II: 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. (25 Marks)

Unit III: Missing plot technique: analysis of RBD and LSD with one and two missing observations. Split plot design- concept and analysis.
Factorial experiments: advantages, notations and concepts,
$2^2, 2^3 and\ 2^n$ factorial experiments- design and analysis; Advantages of factorial over simple experiment with example. Confounding in Factorial experiment: Concept only.

(25 Marks)

Minor – 5: Survey Sampling and Design of Experiment (Practical)

Credit-1 (25 Marks)

List of Practical:

1. To select an SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods
5. Compare the efficiencies of above two methods relative to SRS
6. Estimation of gain in precision in stratified sampling.
7. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
8. Analysis of a CRD
9. Analysis of an RBD
10. Analysis of an LSD
11. Analysis of an RBD with one and two missing observation
12. Analysis of an LSD with one missing observation
13. Analysis of 2^2 and2^3 factorial in CRD and RBD
14. Analysis of 2^2 and2^3 factorial in LSD

Recommended books and references:

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
2. Daroga Singh & F. S. Choudhury: Theory and Sample Survey Designs. Wiley Eastern Limited.
3. Choudhury, Sarma, Deka, Gogoi. An Introduction to Statistics.
4. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
5. Sukhatme,P.V., Sukhatme, B.V. Sukhatme,S. Ashok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
6. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
7. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
8. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.

Semester –VI

Major 12: Stochastic Processes and Queuing Theory (Theory) Credit-3 (75 Marks)

Unit 1: Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process, Hazard and Survival functions. Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalisation of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach. (25 Marks)

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. (25 Marks)

Unit IV: Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof), Gambler's Ruin Problem: Classical ruin problem, expected duration of the game. (25 Marks)

Major 12: Stochastic Processes and Queuing Theory (Practical) Credit-1 (25 Marks)
List of Practical:

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
12. Calculation of generating function and expected duration for different amounts of stake.
13. Computation of probabilities and expected duration between players

Recommended Books and References

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.

Major 13: Design of Experiments (Theory) Credit-3 (75 Marks)

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.
Missing plot technique: analysis of RBD and LSD with one and two missing observations. Split plot design- concept and analysis. (25Marks)

Unit II: Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) - parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD. (25Marks)

Unit III: Factorial experiments: advantages, notations and concepts, $2^2, 2^3, 2^n (n \leq 5)$ *and* 3^2 factorial experiments- design and analysis; Advantages of factorial over simple experiment with example. Confounding in Factorial experiment: Concept of confounding in a design of experiment, confounding subgroups, determination of suitable confounding subgroups, complete and partial confounding with examples for 2^n (n$\leq$ 5); Orthogonality of a design: Distinction between orthogonality and confounding. (25 Marks)

Major 13: Design of Experiments (Practical) Credit-1 (25 Marks)

List of Practical

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. analysis of an RBD with one and two missing observation
5. Analysis of an LSD with one missing observation
6. Intra Block analysis of a BIBD
7. Analysis of 2^2 and2^3 factorial in CRD and RBD

8. Analysis of 2^2 and2^3 factorial in LSD
9. Analysis of a completely confounded two level factorial design in 2 blocks
10. Analysis of a completely confounded two level factorial design in 4 blocks
11. Analysis of a partially confounded two level factorial design

Recommended Books and References

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

Major 14: Operations Research (Theory) Credit-3 (75 Marks)

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: Dual simplex method. Post – optimality analysis. (25 Marks)

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.

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

(25 Marks)

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 to rectangular game with mixed strategy.

Network Analysis: Idea of network node, activities, dummy activity, construction of network diagram; CPM- Network scheduling using CPM, determination of different types of floats and slacks, determination of Critical path; PERT; Basic definition of PERT and its usefulness; brief idea of optimistic time, pessimistic time and most likely (PERT calculations are not required).

(25 Marks)

Major 14: Operations Research (Practical) **Credit-1 (25 Marks)**

List of Practical

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. Post-optimality
    a. Addition of constraint
    b. Change in requirement vector
    c. Addition of new activity
    d. Change in cost vector
4. Allocation problem using Transportation model
5. Allocation problem using Assignment model
6. Networking problem
    a. Minimal spanning tree problem
    b. Shortest route problem
7. Problems based on game matrix
    a. Graphical solution to mx2 / 2xn rectangular game
    b. Mixed strategy
8. To find optimal inventory policy for EOQ models and its variations

9. To solve all-Units quantity discounts model.
10. Problems related to Network analysis.

Recommended Books and References

1. S. D. Sarma (2017). Operations Research. Kedar Nath Ram Nath, Meerut – 250001, UP
2. Mohanty & Patel (2017). Operations Research. Scientific Publishers, Jodhpur - 342001
3. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
4. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
5. Hadley, G: (2002) : Linear Programming, Narosa Publications
6. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research-Concepts and cases, 9th Edition, Tata McGraw Hill

Major 15: Research Methodology **Credit-4 (100 Marks)**

Unit I: Research Methodology: An Introduction, Meaning, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, Defining the Research Problem, Research Design: Meaning, Need, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs. (25 Marks)

Unit II: Sampling Design: Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, How to Select a Random Sample, Random Sample from an Infinite Universe, Complex Random Sampling Designs. Sample Size and its Determination, Measurement and Scaling Techniques: Measurement in Research, Measurement Scales: Nominal, Ordinal, Interval, Ratio. (25 Marks)

Unit III: Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method, Processing and Analysis of Data : Processing Operations, Some Problems in Processing, Elements/Types of Analysis , Statistics in Research: Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes (Concepts only). (25 Marks)

Unit IV: Hypothesis, Qualities of a good Hypothesis, Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance, Procedure for Hypothesis Testing: Z- test, t-test, F-test, Chi square test, Analysis of Variance (ANOVA), Non parametric test, Interpretation of Data and Paper Writing – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish, Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software for detection of Plagiarism. Simulation methods: Monte Carlo simulation. (25 Marks)

Recommended Books and References

1. Wasserman, L. (2004). All of Statistics – A Concise Course in Statistical Inference. Springer Science + BuisnessMedia, New York.
2. Agarwal, C.C. (2017). Outlier Analysis. Springer Cham, New York.
3. Good, P.I. (2006). Resampling Methods A Practical Guide to Data Analysis, Barkhauser Boston, MA, USA.
4. Little, R.J.A and Rubin, D.B. (2019). Statistical Analysis with Missing Data. Wiley, New York.
5. Olkin, I. (1985). Statistical Methods for Meta Analysis, Academic Press, USA.
6. ICMR-National Institute of Medical StatisticsMS. (2021). National Guidelines for Data Quality in Surveys. New Delhi: ICMR-NIMS.
7. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
8. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.

Minor-6: Applied Statistics (Theory) **Credit-3 (75 Marks)**

Unit I: Quality: Definition, dimensions of quality. Statistical Quality Control: concepts**,** Statistical Process Control - Seven tools of SPC, Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, σ - chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability. (25 Marks)

Unit II: 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. Cost of living (Consumer price) index number, problems in the construction of consumer price index number and its uses; Wholesale price index number. Index of Industrial Production, agricultural production. (25 Marks)

Unit III: Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Types of data required for estimating elasticity: family budget data and time series data; Pareto's law of income distribution; Engel's law and Engel's curve; Lorentz curve.

Educational and Psychological Statistics: Scaling of individuals for items in terms of difficulty, Z-score, standard score normalized scores, T-score and percentile score; Scaling of ratings in terms

of normal probability curve; Test theory, Methods of estimating test reliability; Effect of test length on reliability of a test, validity of test scores, Intelligent quotient and its construction.

(25 Marks)

Minor-6: Applied Statistics (Practical) **Credit-1 (25 Marks)**

List of Practical:

1. Construction and interpretation of statistical control charts X-bar & R-chart X-bar & s-chart np-chart p-chart c-chart u-chart
2. Calculate price and quantity index numbers using simple and weighted average of price relatives.
3. To calculate the Chain Base and consumer price index numbers.
4. Fitting of demand curve.
5. Fitting of Pareto's curve.
6. Calculation of Z-Score.
7. Calculation of T-Score.
8. Calculation of percentile score.

Recommended Books and References:

1. Fundamentals of Statistics. S.C. Gupta, Sultan Chand and Co.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
4. Sur & Baneerjee (2023). Basic Statistics. Global Net Publications, Ansari Road, New Delhi -110002.
5. Parimal Mukhopadhyay. Applied Statistics, Books & Allied Ltd.
6. Veer Bala Rastogi. Biostatistics, Medtech; 3rd edition (6 July 2015)

Semester –VII

Major – 16 Mathematical Analysis (Theory) **Credit-4 (Marks 100)**

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, neighbourhoods and limit points, Superimum and infimum, derived sets, open and closed sets. (25 Marks)

Unit II: Sequences and their convergence, limits of some special sequences and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence. (25 Marks)

Unit III: Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} 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. (25 Marks)

Unit IV: 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 sinx, cosx, e^x, log (1+x). (25 Marks)

Recommended books and references:

1. Sudhir K. Pundir (2015). Mathematical Analysis. C.B.S. Publishers and Distributor, Ansari Road, New Delhi -110002.
2. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
3. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
4. Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi, 1995.
4. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi, 1987.
5. Shanti Narayan: A course of Mathematical Analysis, 12^{th} revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24^{th} Edition, R. Chand & Co., New Delhi, 2003.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis(3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis,Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
10. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.

11. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.

Major – 17: Statistical Quality Control (Theory) Credit-3 (75 Marks)

Unit I: Quality system and standards: Introduction to ISO quality standards, Quality registration. Quality control and Sampling Inspection: Basic concepts of process monitoring and control, General theory and review of control charts, O.C and ARL of control charts, CUSUM charts using V-mask and decision intervals, economic design of x- bar chart. (25 Marks)

Unit II: Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.
Sequential Analysis: Wald's Sequential probability ratio test (SPRT). Fundamental relation among α, β, A and B. Determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions.
(25 Marks)

Unit III: Total Quality Management (TQM): Total quality control (TQC), need for management of product quality, Historical perspective of quality control, Concept of Total Quality Management, TQM philosophies, Deming's approach, Juran's ten steps to quality improvement, Juran's trilogy, Taguchi philosophy, Crosby's 14 steps, Shikawa'a Contribution to TQM, TQM models, Principal objectives of TQM, Dimensions of TQM, TQM operation, Zero defect concept, Some guiding principles of TQC/TQM, Implementation of TQM, Training for quality management, Benefits of TQM, ISO:9000 and TQM, Tools and techniques of TQM, Six sigma concept: Introduction, History, definition, Objectives of six sigma, Sigma quality level, Benefits of six sigma, Lean manufacturing, Diffference between TQM and six sigma, Organizational Structure and Six Sigma training plans. (25 Marks)

Major – 17: Statistical Quality Control (Practical) Credit-1 (25 Marks)
List of Practical

1. Construction and interpretation of statistical control charts X-bar & R-chart
   X-bar & s-chart np-chart p-chart c-chart 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 control limits with specification limits.
4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.
5. SPRT procedure
6. OC function and OC curve
7. ASN function and ASN curve

Recommended books and references:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. M.S. Mahajan, (2016): Statistical Quality Control, Dhanpat Rai & Co. (P) Limited.
3. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
4. Mukhopadhyay, P (2011):Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.
5. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.
7. Fundamentals of Mathematical Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi
8. Fundamentals of Applied Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi

Major – 18: Applied Multivariate Analysis (Theory) Credit-3 (75 Marks)

Unit I: Distribution of linear and quadratic forms in normal variables, expectations, variances and covariances, characteristic functions, independence of quadratic forms, conditions for a quadratic form to be distributed as chi-square and non-central chi-square, decomposition of quadratic forms.

(25 Marks)

Unit II: MLEs of the parameters of multivariate normal distribution and their sampling distributions, Wishart distribution and its properties, tests of hypothesis about the mean vector of a multinormal population, Hotelling's T^2 - statistic, its distribution and applications.

Classification and discrimination for two known populations: Bayes', minimax and likelihood ratio procedures, Mahalonobis D^2 - statistic and its application, sample discriminant function and discrimination based on Fisher's method, cluster Analysis and evaluation of clusters.

(25 Marks)

Unit III: Introduction to principal component analysis, canonical correlation analysis, factor analysis, MANOVA and its applications (sans derivation of the distribution of Wilk's λ).

(25 Marks)

Major – 18: Applied Multivariate Analysis (Practical) Credit-1 (25 Marks)

List of Practical:

1. Practical on Hotelling's T^2 – statistic.
2. Practical on Mahalonobis D^2 – statistic.

3. Practical on principal component analysis, canonical correlation analysis, factor analysis, and MANOVA.

Recommended Books and References

1. Anderson, T.W. (1983). An Introduction to Multivariate Statistical Analysis, Wiley Eastern, New Delhi.
2. Johnson, R. and Wychern, D.W. (2002). Applied Multivariate Statistical Analysis, Pearson Education, Delhi.
3. Rao, C.R. (1995), Linear Statistical Inference, Wiley Eastern, New Delhi.
4. Sharma, S. (1996). Applied Multivariate Techniques. John Wiley, New York.
5. Singh, B.M. (2002). Multivariate Statistical Analysis, South Asian Publishers, New Delhi.
6. Giri, N.C. (1977). Multivariate Statistical Inference. Academic Press, New York.
7. Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker, New York.
8. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley, New York.
9. Seber, G. A. F. (1984). Multivariate Observations, John Wiley, New York.

Major – 19: Econometrics (Theory) Credit-3 (75 Marks)

Unit I: Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions. (25 Marks)

Unit II: Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error. (25 Marks)

Unit III: Generalized least squares estimation, Aitken estimators, Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation. 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, Dummy variables, Qualitative data.
(25 Marks)

Major – 19: Econometrics (Practical) Credit 1 (25 Marks)

List of Practical

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems concerning specification errors
5. Problems related to consequences of Multicollinearity

6. Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Diagnostics of Autocorrelation
9. Estimation of problems of General linear model under Autocorrelation
10. Problems related to consequences Heteroscedasticity
11. Diagnostics of Heteroscedasticity
12. Estimation of problems of General linear model under Heteroscedastic distance terms
13. Problems related to General linear model under (Aitken Estimation)
14. Problems on Autoregressive and Lag models.

Recommended Books and References

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.

Minor – 7: Demography (Theory) **Credit-3 (75 Marks)**

Unit I: Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan- Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio. Migration: definition and kind of migration, estimation of migration rates, components of Migration.

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 Standardised Death Rates. Stationary and Stable population, Central Mortality Rates and Force of Mortality.

(25 Marks)

Unit II: Life (Mortality) Tables: Assumption, description, construction of Life Tables and uses of Life Tables. Double and multiple decrement life table, indirect estimation of life expectancy, model life tables. Abridged Life Tables: Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. 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). (25 Marks)

Unit III: 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. Indian agricultural statistics, Industrial statistics. Concept of National Accounts Statistics (GDP, NDP, GNP and NNP). (25 Marks)

Minor – 7: Demography (Practical) Credit-1(25 Marks)
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 fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them
9. To calculate the probability of dying from a particular cause of death (multiple decrement life table).

Recommended Books and References

1. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
2. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
4. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
6.Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.
Bhende A.A. Kanitkar Tara: Principles of Population Studies, Himalayan Publishing House, Mumbai-400004.

Semester –VIII

Major – 20: Numerical Analysis and Bivariate Normal Distribution (Theory)
Credit-3 (75 Marks)

Unit I: Numerical Differentiation: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. (25 Marks)

Unit II: Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.
Numerical Roots of Polynomial and Transcendental Equation: Bisection Method. Iteration method, Regula-falsi method, Secant method, Newton-Raphson's method. (25 Marks)

Unit III: 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. (25 Marks)

Major – 15: Numerical Analysis and Bivariate Normal Distribution (Practical)
Credit-1 (25 Marks)

List of Practical

1. Bivariate Normal Distribution and Multivariate Normal Distribution
2. Practical on Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae.
3. Practical on Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Weddle's rule.
4. Practical on Bisection Method. Iteration method, Regula-falsi method, Secant method, Newton-Raphson's method.

Recommended Books and References

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1st Edn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edn., Pearson & Prentice Hall
5. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific

6. and engineering computation, New age International Publisher, India.
7. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
8. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi

Major 21: Reliability Theory (Theory) Credit-3 (75 Marks)

Unit I: Reliability concepts and measures; components and systems, coherent systems; reliability coherent systems, cuts and paths, modular decomposition, bounds and system reliability; structural and reliability importance components.
Failure time distributions; reliability function, hazard rate, common failure time distributions; exponential, Weibull, gamma etc., estimation of parameters and tests in these models, notions of ageing. (25 Marks)

Unit II: Increasing failure rate (IFR). Increasing failure rate average (IFRA), not better than used (NBU), decreasing mean residual life (DMRL) and not better than used in expectation (NBUE), classes and their duals; loss of memory property of the exponential distribution; closures of these classes under formation of coherent systems, convolutions, and mixtures. (25 Marks)

Unit III: Univariate shock models and the distributions arising out of them; bivariate shock models, common bivariate exponential distributions and their properties, reliability estimation based on failure times in censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.
(25 Marks)

Major – 19: Reliability Theory (Practical) Credit 1 (25 Marks)
List of Practical:
1. Practical based on common failure time distributions: exponential, Weibull, gamma etc.
2. Practical based on IFR, IFRA.

Recommended Books and References
1. Bain L.J. (1991) Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker, New York.
2. Barlow R.E. and Proschan, F. (1985). Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.
3. Lawless, J.F. (1982). Statistical Models and Methods of Life Time Data, John Wiley, New York.
4. Nelson, W. (1982). Applied Life Data Analysis, John Wiley, New York.

Major 22: Biostatistics and Epidemiology (Theory) Credit-3 (75 Marks)

Unit I: A Basic Concept in Epidemiology: Introduction: Definition and objectives of epidemiology; Epidemiology and clinical practice; The epidemiologic approach; Infectious disease epidemiology, occupational epidemiology, disaster epidemiology.

The dynamics of disease transmission: Modes of transmission; epidemic, endemic and pandemic; Disease outbreak; Determinants of disease outbreak; Herd immunity; incubation period; outbreak investigation; epidemiological modelling. Identifying the roles of genetic and environmental factors in disease causation: Association with known genetic diseases; Age at onset; Family studies; Interaction of genetic and environmental factors. Epidemiology and public policy: Epidemiology and prevention; Population versus high-risk approaches to prevention; epidemiology and clinical medicine; Risk assessment; Meta Analysis. Epidemiological Study Designs: Ecological, Cross-Sectional, Case-Control, Cohort Studies, Randomized Intervention Studies. Experimental epidemiology; Randomized trials. (25 Marks)

Unit II: Clinical Trials- Basic concepts; Definitions; Historical perspectives, Phase I, II, III and IV trials, Protocol development, Use of control arms, Concepts of randomization and blinding, ethical issues.

Measurement of Health & Disease Burden: Measuring the occurrence of disease: Measures of morbidity - prevalence and incidence rate, association between prevalence and incidence, uses of prevalence and incidence, problems with incidence and prevalence measurements; Surveillance; Quality of life including DALY, HALE, etc.

Measures of mortality. Assessing the validity and reliability of diagnostic and screening test: Validity of screening test – sensitivity, specificity, positive predictive value and negative predictive value. (25 Marks)

Unit III: Reliability; Relationship between validity and reliability; ROC curve and its applications; Overall accuracy. Issues in epidemiology: Association; causation; causal inference; Errors and bias; Confounding; Controlling confounding; Measurement of interactions; Generalizability**.**

Estimating risk: Estimating association – absolute risk, relative risk, odds ratio; Estimating potential for prevention – attributable risk; comparison of relative risk and attributable risk; Odds ratios for retrospective studies; Odds ratios approximating the prospective RR; Exact inference for odds ratio analysis of matched case-control data.

Modelling of Infectious Disease Process: Infectious diseases of human – malaria, tuberculosis, Hepatitis, HIV/AIDs, Deterministic modeling of infectious diseases.

Profit and Survival Analysis Concepts and definition of Survival analysis - Kaplan-Meir, Life table method, Mantel-Haensal, method, Cox proportional hazards method, Dose response analysis. (25 Marks)

Major – 19: Biostatistics and Epidemiology (Practical) Credit 1 (25 Marks)

List of Practical:

1. Practical on measures of morbidity.
2. Practical on measures of mortality.
3. Practical on Survival analysis.

Recommended Books and References

1. Last J M: A Dictionary of Epidemiology, ed. 2. New York, Oxford University Press, 1988.
2. Bonita R, Beaglehole R, Kjellstrom T: Basic Epidemiology, ed. 2. World Health Organization,2006.
3. Park LE, Park K: Textbook of Preventive and Social Medicine. Jabalpur, Banarasidas Bhanot,1986.
4. Dunn G, Everitt B: Clinical Biostatistics: An Introduction to Evidence-based Medicine. EdwardArnold, 1995.
5. Friedman L M, Furberg C D, DeMets D L: Fundamentals of Clinical Trials. Boston, PSG, 1982.
6. MacMahon B, Pugh T F: Epidemiology: Principles and Methods. Boston, Little Brown, 1970.
7. Gordis L: Epidemiology, ed. 3. Philadelphia, 2004.
8. Rosner B: Fundamentals of Biostatistics, ed. 6, 2006.
9. Altman D G: Practical Statistics for Medical Research, London: Chapman and Hall, 2006.
10. United Nations Department of Economic and Social Affairs: Designing Household SurveySamples.United Nations, 2005.
11. Lee E T: Statistical Methods for Survival Data Analysis, ed. 2. New York, John Wiley &Sons.
12. Goldstein H: Multilevel Statistical Model. London, Institute of Education, 1999.
13. Murray C J L, Chen LC: Understanding morbidity change. In Arthur Kleinmann and Norma C Wane (eds.) Health and Social Change in International Perspective, Harvard Series on Population and International Health, March 1994.
14. Pocock S J: Clinical Trials: A Practical Approach. Michigan, Wiley Medical Publication, 1983.
15. Everitt B S, Pickles A: Statistical Aspects of the Design and Analysis of Clinical Trials, ed. 2. London, Imperial College Press.
16. Wackerly DO, Mendenhall W, Scheaffer RL: Mathematical Statistics with Applications, 7th edition, Wadsworth Publishing Co Inc, 2007.
17. Kutner MH, Nachtsheim CJ, Neter J, Li W: Applied Linear Statistical Models. 5th edition, McGrawHill/Irwin, 2005.
18. Gelman A, Carlin JB, Stern HS, Rubin DB, Dunson DB, Vehtari A: Bayesian Data Analysis, 3rd ed. Chapman and Hall, 2013.
19. Van Der Vaart: Asymptotic Statistics. Cambridge University Press, 2000.

20. Groeneboom P: Nonparametric Estimation under Shape Constraints, Cambridge University Press; 1

Major 23: Statistics for Sustainable Development (Theory) Credit -4 (100 Marks)

Unit I: Economic Growth and Sustainable Development, alternative definitions and concepts of sustainability; Social Equity and Environmental protection. UN adopted Sustainable Development Goals (SDGs), SDG indicators and Data Sources. (25 Marks)

Unit II: Role of data and statistics in evidence based policy making, National and International Statistical systems – their roles for capacity building, existing data gaps for goals, monitoring and evaluation of SDGs and targets, development and implementation of the SDGs from a range of theoretical, policy and practical perspectives. Country level adoption within an international, domestic and global context. (25 Marks)

Unit III: Concept of Human Development, human development index (HDI) and its dimensions and compositions, HDI and its link with SDGs, Physical Quality of Life Index, Gender- equity Index. (25 Marks)

Unit IV: SDG1 and poverty, global Multidimensional Poverty Index (MPI) of UNDP, Composition of MPI and deprivation indicators, Measurement and trends in MPI, disaggregated analysis of MPI and assessment of progress towards SDG1 – examples and case studies. (25 Marks)

Recommended Books and References

1. Jennifer A. Elliot, (2013). An Introduction to Sustainable Development, 4th Ed, Routledge, New York.
2. Willies, K., (2011). Theories and Practices of Development, 2nd ed., Routledge, New York.
3. Hartmut, B., (1999). Indicators for sustainable development: Theory, Method and applications, IISD, Canada.
4. UNDP &OPHI(2020). Global Multidimesional Poverty Index 2020: Charting Pathways outof Multidimensional Poverty : Achieving the SDGs, https://ophi.org.uk/multidimensional-poverty-index/.
5. United Nations(2015). Transforming Our World: The 2030 Agenda for Sustainable Development,https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981.
6. United Nations (2020). The Sustainable Development Goals Report 2020. https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.
7. General Economics Division (GED), Bangladesh Planning Commission (2017), Data Gap Analysis of Sustainable Development Goals (SDGs): Bangladesh Perspective, Government of the People's Republic of Bangladesh.
8. Kusters, C.S.L. and Batjes, K. with Wigboldus, S., Brouwers, J. and Baguma, S.D. (2017) Managing for Sustainable Development Impact: An Integrated Approach to Planning, Monitoring and Evaluation, Wageningen: Wageningen Centre for Development Innovation,

Wageningen University & Research, and Rugby, UK: Practical Action Publishing, http://dx.doi.org/10.3362/9781780449807.

Minor-8: Time Series Analysis (Theory) **Credit-3 (75 Marks)**

Unit I: Introduction to times series data, application of time series from various fields, components of times series, Decomposition of time series. 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. Seasonal Component: Estimation of seasonal component by Method of Simple averages, Ratio of Trend, Ratio to moving Averages and Link Relative method, Deseasonalisation. (25 Marks)

Unit II: Cyclic Component: Harmonic Analysis. Multicolinearity: Nature, Estimation of parameters and detection of multicolinearity. Random component: Variate component method. Forcasting: Exponential smoothing methods, Short term forcasting methods: Brown's discounted regression, Box- Jenkins method and Bayesian forecasting. (25 Marks)

Unit III: Autocorrelation: Autocorrelation function and correlogram, Stationary Time series: Weak stationary. Autoregression: Moving average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2)- Yule walker equations. (25 Marks)

Minor-8: Time Series Analysis (Practical) **Credit-1 (25 marks)**

List of Practical

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Calculation of variance of random component by variate difference method
9. Forecasting by exponential smoothing
10. Forecasting by short term forecasting methods.

Recommended Books and References:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied
3. S.C. Gupta and V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand and Co.
Damodar N. Gujarati. Basic Econometrics. Mc. Graw Hill International.