Revised Syllabus according to NEP 2022

DEPARTMENT OF STATISTICS
COTTON UNIVERSITY

**DEPARTMENT OF STATISTICS
COTTON UNIVERSITY**

FOUR YEARS UNDER GRADUATE PROGRAME

Effective from – 2023 – 2024

Course Overview
DEPARTMENT OF STATISTICS
COTTON UNIVERSITY
Four Year Undergraduate Syllabus

Semester	Paper Code	Paper Title	Credit (L+T+P)
I	STA101C / STA 102 GE	Statistical Methods	3+0+1
II	STA201C / STA 202 GE	Probability I	4+0+0
III	STA301C	Probability II	3+0+1
	STA302C	Calculus	4+0+0
	STA 303 GE	Probability Distribution	3+0+1
IV	STA401C	Algebra	4+0+0
	STA402C	Foundation of Statistical Inference and Testing	3+0+1
	STA403C / STA 404 GE	Applied Statistics	3+0+1
SEC	STA 001 SEC	Data Analysis using Microsoft Excel™	0+0+3
	STA 002 SEC	Data Analysis using IBM SPSS™	0+0+3
	STA 003 SEC	Introduction to Statistical Computing Using R	0+0+3
MDE	STA 001 MDE (For Semester I and II)	Introduction to Statistics	3+0+0
	STA 002 MDE (For Semester III)	Introduction to Applied Statistics	3+0+0

Semester I
STA 101 C / 102 GE
(Major / Minor)
Statistical Methods
Credit 4 (3+0+1)

Course Learning Objective:
- To summarize the data and to obtain its salient features from the vast mass of original data.
- To understand the concept of relationships between variables.
- To understand the concept of attributes.
- To understand the different types of index numbers and its computation.

Course Learning Outcomes:
After completing this course, the students should have developed a clear understanding of:
- Concepts of statistical population and sample, variables and attributes.
- Diagrammatic and graphical representation of data based on variables.
- Measures of central tendency, Dispersion, Skewness and Kurtosis.
- Moments and their use in studying various characteristics of data.
- Bivariate data and study of relationships between variables by using correlation and regression.
- Conditions for the consistency' and criteria for the independence of data based on attributes.
- Computation of different types of index numbers, Consumer Price Index number, Chain Index number, Splicing and Deflating of Index number.

UNIT I (Lectures: 14)
Introduction to Statistics: Definition, scope and limitations of Statistics (Only assignments to be submitted). Official Statistics (Only assignments to be submitted). Concepts of statistical population and sample. Data: Primary and Secondary, Quantitative and Qualitative, Cross-sectional, Spatial and Time series data. Variables: discrete and continuous, Scales of measurement- nominal, ordinal, interval and ratio. Presentation of data: Classification, tabulation, frequency distribution, diagrammatical and graphical representation. Stem and leaf chart, Box plot.

UNIT II (Lectures: 14)
Measures of Central Tendency and Dispersion: Mean (Arithmetic, Geometric, Harmonic), Median, Mode, Partition Values. Measures of Dispersion: Range, Quartile Deviation, Mean Deviation, Standard Deviation, Coefficient of Variation. Moments: Raw, Central, Absolute, Factorial, Sheppard's corrections. Skewness and Kurtosis.

UNIT III (Lectures: 12)
Analysis of Bivariate data: Definition, Scatter diagram, Karl Pearson's correlation coefficient, Rank correlation, Correlation - partial and multiple (3 variables only), Idea of Intra class correlation and Correlation ratio. Principle of least squares and fitting of first- & second-degree polynomials and exponential curves, Simple linear regression.

UNIT IV (Lectures: 8)
Analysis of Categorical Data: Consistency of data, independence, and association of attributes. Measures of association - Yule's, Pearson's and Goodman-Kruskal's coefficients, Idea of Odds Ratio.

PRACTICAL/ LAB. WORK:
(Credit: 1) (Lectures: 16)

List of Practical
1. Diagrammatic representation of data.
2. Graphical representation of data.
3. Problems based on measures of central tendency.
4. Problems based on measures of dispersion.
5. Problems based on combined mean, variance, and coefficient of variation.
6. Problems based on moments, skewness, and kurtosis.
7. Fitting of polynomials, exponential curves.
8. Karl Pearson's correlation coefficient.
9. Correlation coefficient for a bivariate frequency distribution.
10. Lines of regression, angle between lines and estimated values of variables.
11. Spearman's rank correlation with and without ties.
12. Fitting of first- & second-degree polynomials and exponential curves.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2019): Fundamentals of Statistics, Vol. I & II, The World Press, Kolkata.
2. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.
3. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
5. Gupta S.C., Kapoor V.K.(2007): Fundamentals of Applied Statistics. 4th Edition, Sultan Chand and Sons., New Delhi.
6. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
7. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.

SEMESTER 2
STA 201 C/202 GE
(Major/Minor)
Probability I
Credit 4 (4+0+0)

Course Learning Objective:

The purpose is to familiarize the students with
- The concept of probability and the various related definitions
- Probability distributions for both discrete and continuous random variables.
- The concept of Mathematical expectation.
- Generating functions and their properties.

Course Learning Outcomes:

After completing this course, there should be a clear understanding of:
- Probability, events and algebra of events, addition and multiplication theorems
- Conditional probability, Independence of events and related theorems, including Bayes theorem.
- How to solve problems on probability.
- P.m.f. p.d.f., c.f., two dimensional random variables, joint, marginal and conditional distributions.
- Mathematical expectation and related theorems.
- Generating functions

UNIT I (Lectures: 24)

Probability: Introduction, random experiments, sample space, events- different types of events and algebra of events. Definitions of Probability– classical, statistical and axiomatic. Conditional probability, independence of events, laws of addition and multiplication (up to n events), theorems of total and compound probability, Boole's inequality, Bayes' theorem and its applications.

UNIT II (Lectures: 16)

Random variables: discrete and continuous, probability distributions of random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables. 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. Univariate and bivariate transformations with illustrations.

UNIT III (Lectures: 14)
Mathematical Expectation: Expectation of single and bivariate random variables and its properties, Theorems on sum and product of expectation of random variables, Moments, Measures of location and dispersion of random variables, Conditional expectations and Conditional variance.

UNIT IV (Lectures: 10)
Generating Functions: moment generating function, cumulant-generating function, characteristic function and probability generating function. Uniqueness and inversion theorems (without proof) along with applications.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. The World Press, Kolkata.
2. Ross, S. M. (2012). A First Course in Probability (9th ed.). Pearson.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, 7th Ed, Pearson Education, New Delhi.
5. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
6. Rohatgi V.K (2009): An introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons.
7. Ross, S. M. (2020). Introduction to Probability models. 11th Edn. Academic Press.

SEMESTER 3
STA 301 C (Major)
Probability II
Credit 4 (3+0+1)

Course Learning Objectives:

The purpose is to familiarize the students

- About different standard probability distribution for both discrete and continuous random variables.
- To give knowledge about various Limit Laws of large numbers.

Course Learning Outcomes:

After completing this course, there should be a clear understanding of:

- Knowledge of important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hypergeometric and their interrelations.
- Knowledge of important continuous distributions such as Uniform, Normal, Exponential, Lognormal, Laplace, Weibull, Gamma, Beta and Cauchy distributions along with their characteristic properties and limiting/approximation cases.
- Some probability inequalities, Laws of convergence, their inter relations and applications law of large numbers.
- Central Limit Theorem and its applications.

UNIT I (Lectures:14)

Discrete Probability Distributions: Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric distributions along with their characteristic properties and limiting/approximation cases.

UNIT II (Lectures: 14)

Continuous probability distributions I: Normal, Exponential, Lognormal, Laplace and Weibull distributions along with their characteristic properties and limiting/approximation cases.

UNIT III (Lectures: 10)

Continuous probability distributions II: Uniform, Gamma, Beta, Cauchy distributions along with their characteristic properties and limiting/approximation cases.

UNIT IV (Lectures:10)
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 (Lindeberg–Levy), Applications of C.L.T. and Liapunov Theorem (without proof).

PRACTICAL/ LAB. WORK:
(Credit: 1) (Lectures: 16)

List of Practical
1. Fitting of Binomial distribution for n and p = q = ½
2. Fitting of Binomial distribution for given n and p.
3. Fitting of Binomial distribution after computing mean and variance
4. Fitting of Poisson distribution for given value of lambda
5. Fitting of Poisson distribution after computing mean
6. Fitting of Normal distribution when parameters are given.
7. Fitting of Normal distribution when parameters are not given.
8. Fitting of Exponential distribution.

SUGGESTED READING:

1. Feller, W (1993): An Introduction to Probability Theory and its Applications, Vol I, 9th Edition, Wiley Eastern Publication.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.16
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Bose, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata McGraw-Hill Pub. Co. Ltd.
6. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
7. Ross, S. M. (2020). Introduction to Probability models. 11th Edn. Academic Press.
8. Hunter, J. J. (1999). Mathematical techniques. Volume 1 & 2. John Wiley & Sons.

STA302C (Major)
Calculus
Credit 4 (4+0+0)

Course Learning Objective:

The learning objectives include:
- Fundamentals of differential calculus, Integral calculus, Differential Equations, and Partial differential equations.
- To analyse the problem and its solution.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:
- The fundamental concepts of Differential calculus and techniques of differentiation,
- The concept of Successive differentiation, n^{th} derivative of the product of two functions, total and partial differentiation.
- Procedure of finding maxima and minima for functions involving one and more than one variable.
- The fundamental concepts of Integral calculus and techniques of Integration.
- Beta and Gamma functions: properties and relationship between them.
- Differentiation under integral sign, double integral, changes of order of integration, transformation of variables, Jacobian.
- Finding complete solutions of first and second order ordinary differential equations.
- Searching solution of partial differential equation.

UNIT I (Lectures: 20)
Differential Calculus: Limits of functions, continuous functions, properties of continuous functions, differentiation. (Only assignments to be submitted for this part)

n^{th} order differentiation, Partial differentiation and Total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems, concavity and convexity, points of inflexion of function, singular points.

UNIT II (Lectures: 12)
Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double integral, changes of order of integration, transformation of variables, Jacobian. Beta and Gamma functions: properties and relationship between them.

UNIT III (Lectures: 24)
Ordinary Differential Equations: Order and Degree of a differential equations, Linear and non-linear differential equations; First order linear differential equations-integrating factor, existence and uniqueness theorem for initial value problems; First order non-linear differential equations-separation of variable method, exact differential equations, equations reducible to exact form, Bernoulli's equation, equations solvable for x and y, Clairaut's equation; Second Order Differential Equations- Linear differential equations of order 2, Homogeneous and non-homogeneous linear differential equations of order 2 with constant coefficients, Linear differential equations with variable coefficients, variation of parameter method.

UNIT IV (Lectures: 8)
Partial Differential Equations: Partial Formation and solution of a partial differential equation. Equations easily integrable. Linear partial differential equations of first order. Method of characteristics for solving linear partial differential equations.

SUGGESTED READING:

1. Hass Joel, Heil Christopher, Weir Maurice D. (2018): Thomas' Calculus, Pearson, 14th Edition.
2. Malik S.C. and Arora Savita (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
3. Marsden Jerrold E., Tromba A. J., Weinstein A. (2005): Basic Multivariable Calculus, Springer.
4. Boyce W., DiPrima R. C. (2009): Elementary Differential Equations And Boundary Value Problems,Wiley.
5. Ross, S. L. (1984). Elementary Differential Equations (2nd ed.). Wiley.
6. Stewart, J. (2015). Essential Calculus: Early Transcendentals (2nd ed.). Cengage Learning.
7. Larson, R., & Edwards, B. (2013). Calculus (10th ed.). Brooks/Cole, Cengage Learning.
8. Tan, S. T. (2013). Calculus: Early Transcendentals (1st ed.). Brooks/Cole, Cengage Learning.

STA 303 GE (Minor)
Probability Distributions
Credit 4 (3+0+1)

Course Learning Objectives:

The purpose is to familiarize the students
- About different standard probability distribution for both discrete and continuous random variables.
- About various Limit Laws of large numbers.
- To the concept of ordered statistics.

Course Learning Outcomes:

After completing this course, there should be a clear understanding of:
- Knowledge of important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hypergeometric and their interrelations.
- Knowledge of important continuous distributions such as Uniform, Normal, Exponential, Lognormal, Laplace, Weibull, Gamma, Beta and Cauchy distributions along with their characteristic properties and limiting/approximation cases.
- Some probability inequalities, Laws of convergence, their inter relations and applications law of large numbers.
- Central Limit Theorem.
- Order statistics, distribution of some standard ordered statistics.

UNIT I (Lectures: 16)
Discrete probability distributions: Uniform, Bernoulli, Binomial, Poisson, and Geometric distributions along with their characteristic properties and limiting/approximation cases.

UNIT II (Lectures: 16)
Continuous probability distributions: Uniform, Normal, Exponential, Lognormal, and Gamma distributions along with their characteristic properties and limiting /approximation cases.

UNIT III (Lectures: 8)
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. Idea of Central Limit Theorem (C.L.T.).

UNIT IV (Lecture: 8)
Order statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and s^{th} order statistics.

PRACTICAL/ LAB. WORK:
(Credit: 1) (Lectures: 16)

List of Practical
1. Fitting of Binomial distribution for n and p = q = ½
2. Fitting of Binomial distribution for given n and p.
3. Fitting of Binomial distribution after computing mean and variance
4. Fitting of Poisson distribution for given value of lambda
5. Fitting of Poisson distribution after computing mean
6. Fitting of Normal distribution when parameters are given.
7. Fitting of Normal distribution when parameters are not given.
8. Fitting of Exponential distribution.

SUGGESTED READING:

1. Feller, W (1993): An Introduction to Probability Theory and its Applications, Vol I, 9th Edition, Wiley Eastern Publication.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.16
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Bose, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata McGraw-Hill Pub. Co. Ltd.
6. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
7. Ross, S. M. (2020). Introduction to Probability models. 11th Edn. Academic Press.
8. Hunter, J. J. (1999). Mathematical techniques. Volume 1 & 2. John Wiley & Sons.

STA401C (Major)
Algebra
Credit 4 (4+0+0)

Course Learning Objective:
Algebra serves as a building block that will enable students to learn more advanced techniques that will help them to solve problems more quickly and easily.

Course Learning Outcomes:
After completing this course, students should have developed a clear understanding of:
- Theory of Equations.
- The fundamental concepts of Group, Ring, Field, Vector spaces, Sub spaces, Dimension and Basis of vector space.
- The fundamental concepts of matrices and determinants and its properties.
- Echelon form.
- Linear equations.
- Rank of a Matrix.
- Characteristic roots and vectors.
- Quadratic forms.
- Partitioning of matrices.

UNIT I (Lectures: 18)
Introductory Concepts: Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients of any polynomial equations. Idea of Group, Ring and Field. Vector spaces, Subspaces, Algebra of subspaces, Span of a set, Linear dependence and independence, Dimension and Basis, Dimension theorem.

UNIT II (Lectures: 12)
Algebra of matrices: A review, theorems related to triangular, symmetric and skew symmetric matrices, Idempotent matrices, Hermitian and skew Hermitian matrices, Orthogonal matrices, Singular and Non-singular matrices and their properties. Trace of a matrix, Unitary, Involutory and Nilpotent matrices. Adjoint and Inverse of a matrix and related properties. Partitioning of matrices.

UNIT III (Lectures: 10)
Determinants: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Product of determinants.

UNIT IV (Lectures: 24)

Rank, Eigen values and Linear equations: Rank of a matrix, minors of matrix, row reduction and echelon forms, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices.

Linear equations: Use of determinants in solution to the system of linear equations, the matrix equations AX=B, solution sets of linear equations, linear dependence and independence, Applications of linear equations, inverse of a matrix. Characteristic roots and Characteristic vectors, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms.

SUGGESTED READINGS:

1. Graybill, F. A. (1976). Introduction to matrices with statistical applications (2nd ed.). Wadsworth.
2. Vasishtha, A.R. (1982). Matrices (9th ed.). Krishna Prakashan Mandir.
3. Artin M. (1994). Algebra. Prentice Hall of India.
4. Biswas, S. (1997). A Textbook of Matrix Algebra. New Age International.
5. Hadley G. (2002). Linear Algebra. Narosa Publishing House (Reprint).
6. Gupta S.C. (2008). An Introduction to Matrices (Reprint). Sultan Chand & Sons.
7. Schaum's Outlines. (2006). Linear Algebra (3rd ed.). Tata McGraw-Hill Edition.
8. Lay, D. C. (2016). Linear algebra and its applications (5th ed.). Pearson.

STA 402 C
Foundation of Statistical Inference
Credit 4 (3+0+1)

Course Learning Objectives:
The purpose is to familiarize the students
- To understand the process of hypothesis testing.
- To understand about sample Order Statistics.
- To understand the concept of exact sampling distributions and their applications in statistical inference.

Course Learning Outcomes:
After completing this course, there should be a clear understanding of:
- Basic concepts of hypothesis testing, including framing of null and alternative hypothesis.
- To have a clear understanding of when to apply various tests of hypothesis about population parameters using sample statistics and draw appropriate conclusions from the analysis for large samples.
- Hypothesis testing based on a single sample and two samples using both classical and p value approach for small samples.
- Order statistics and distribution of sample median and range.
- How to Analyse categorical data by using Chi square techniques.
- t and F distributions and their applications.

UNIT I (Lectures: 16)
Testing of Hypothesis: Definitions of population, random sample, parameter and statistic, sampling distribution of a statistic, standard error, sampling distribution of sample mean, standard errors of sample mean, and variance.
Tests of significance: Null and alternative hypotheses, simple and composite hypotheses, level of significance, Type I, Type II errors and their probabilities, critical values and critical region. Large sample tests: use of C.L.T for testing single proportion, difference of two proportions, single mean, difference of means and difference of standard deviations by classical and p-value approaches.

UNIT II (Lectures: 14)
Chi – Square Distribution: Definition and derivation of χ^2 (Chi – Square) distribution, nature of the density curve for different degrees of freedom. Mean, variance, m.g.f., c.g.f, mode, additive property and limiting form of χ^2 distribution. Linear transformation, Fisher's lemma, Distribution of $(\bar{X})$ and S^2. Tests of significance and confidence intervals based on the distribution.

UNIT III (Lectures: 12)
Exact Sampling Distributions: Definition and derivation of Student's- t and Fisher's- t distributions, nature of the density curve for different degrees of freedom. Mean, variance, moments and limiting form of t distribution and distribution of correlation coefficient r (null case only). Test of significance and confidence intervals based on t distribution.

Snedecor's F-distribution: Derivation of p.d.f., nature of the density curve for different degrees of freedom, mean, variance and mode. Distribution of $\frac{1}{F(n_1, n_2)}$. Test of significance and confidence Intervals based on F distribution. Relationship between t, F and χ2 distributions.

UNIT IV (Lectures: 06)
Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and s^{th} order statistics, distribution of sample median and sample range.

PRACTICAL/LAB. WORK:
(Credit: 1) (Lectures: 16)

List of Practical
1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means for large samples.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing of goodness of fit.
6. Testing of independence of attributes.
7. Testing based on 2 X 2 contingency table without and with Yates' corrections.
8. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons
4. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
5. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
6. 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.
7. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition,Wiley India Pvt. Ltd.
8. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.

STA 403 C / STA 404 GE
Applied Statistics
Credit 4 (3+0+1)

Course Learning Objective:
- To learn techniques and approach of SQC to be applied in industry to manufacture goods and services of high quality at low cost.
- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility and Population Growth.

Course Learning Outcomes:
The students will be able to
- Understand the concept of Time Series analysis and the components of Time series
- Determine Trend, Seasonal variation and cyclical variation.
- Understand the concept and utility of SQC techniques.
- Construct group control charts.
- Draw charts for variables and attributes.
- Understand single sampling inspection plans, OC and ASN functions.
- Make distinction between Vital Statistics and Demography.
- Identify the source and errors in demographic data.
- Make distinction between Rate and Ratio.
- Calculate basic measures of Mortality, Fertility and population growth.
- Understand the concept of Life Tables, their construction and uses.

UNIT I (Lectures: 12)
Index Numbers: Definition, problems in their construction. Unweighted and weighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Criterion of a good index number. Chain index numbers, conversion of fixed based to chain-based index numbers and vice-versa. Consumer price index numbers: construction and uses. Base shifting, splicing and deflating of index numbers. Uses and limitations of index numbers.

UNIT II (Lecture: 12)
Time Series Analysis: Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Additive and multiplicative models with their merits and demerits.
Trend: Estimation of trend by free hand curve method, method of semi averages, method of moving averages, fitting of various mathematical curves and growth curves (linear, quadratic and modified exponential). Detrending, Effect of elimination of trend on other components of the time series. Estimation of seasonal and cyclical fluctuations.

UNIT III (Lectures: 12)

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

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).

Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables. Abridged Life Tables: Concept and construction of abridged life tables by Reed-Merrell method.

UNIT IV (Lectures: 12)

Statistical Quality Control: Definition and its concept, application and importance. Introduction to Process and Product Control, Seven tools of SPC, Chance and Assignable causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping. Idea of 6-σ limits, Natural tolerance limits and Specification limits. Control charts for variables: X-bar & R-chart, X-bar & s-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, idea of process capability. Concept of acceptance sampling plan.

PRACTICAL/LAB. WORK:
(Credit: 1) (Lecture: 16)
List of Practical

1. Calculation of price and quantity index numbers using simple and weighted average of price relatives.
2. Calculation of Chain Base index numbers.
3. Calculation of consumer price index number.
4. Practical based on shifting of base, splicing and deflating of index numbers.
5. Construction and interpretation of statistical control charts: (a) X-bar & R-chart (b) X-bar & s-chart (c) np-chart (d) p-chart (e) c-chart and (f) u-chart
6. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
7. To calculate CDR and Age Specific death rate for a given set of data.
8. To find Standardized death rate by:
   a. Direct method

b. Indirect method

9. To construct a complete life table.
10. To fill in the missing entries in a life table.
11. To calculate probabilities of death at pivotal ages and use it construct abridged life table using Reed-Merrell Method,
12. To calculate CBR, GFR, SFR, TFR for a given set of data.
13. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
14. Calculate GRR and NRR for a given set of data and compare them.

SUGGESTED READING

1. Hill, T. P., & Judge, G. G. (2018). Index number theory: Stochastic approach. Springer.
2. Brockwell, P. J., & Davis, R. A. (2016). Introduction to time series and forecasting. Springer.
3. Das, S. K., & Das, N. G. (2015). Vital statistics: An introduction to health science statistics. Academic Press.
4. Montgomery, D. C. (2012). Introduction to statistical quality control. John Wiley & Sons.
5. Rao, V. M., & Mitra, A. K. (2019). Theory and practice of cost index number: An accounting perspective. Routledge.
6. Shumway, R. H., & Stoffer, D. S. (2017). Time series analysis and its applications: With R examples. Springer.
7. Teitelbaum, M. S., & Winter, J. S. (2018). Population and development: The demographic transition. University of Chicago Press.
8. Wheeler, D. J. (2017). Understanding statistical process control. SPC Press.

SKILL ENHANCEMENT COURCE
STA 001 SEC
Data Analysis Using Microsoft Excel™
Credit 3 (0+0+3)

Course Learning Objective:
The objective of this course is to:
- Introduce students to spreadsheet software (Microsoft Excel).
- Understand basic statistical calculation using SPSS.

Course Learning Outcomes:
After completion of the course, students will be able to:
- Enter data in Microsoft Excel.
- Import and export data files.
- Visually represent data using different graphs and diagrams.
- Characterize a data set using different descriptive statistics.
- Use different statistical tests to verify hypothesis about population parameters.

Contents (Practical): (Credit: 2)
Unit I (Lectures: 12)
Introduction: Introduction to Microsoft Excel: Entering data, types of data, cell position and reference (absolute and relative). Formula bar, entering formula to a cell, copying formula from a cell. Managing sheets.

Unit II (Lectures: 12)
Visualisation: Diagrammatic and Graphic representation of data (using Pie Diagram, Bar Diagram, Line Diagram and Histogram).

Unit III (Lectures: 12)
Summarizing data: Frequency distribution, Tables. Measures of location: Mean, Median, Mode and Partition values; Geometric Mean and Harmonic Mean. Measures of Dispersion: Range, Mean Deviation, Quartile Deviation, Standard Deviation; Skewness and Kurtosis, Bivariate Data: Scatter plots, Karl Pearson's Coefficient of Correlation, Linear Regression.

Unit IV (Lectures: 12)
Testing Hypothesis: Understanding of hypothesis testing, computation of p-values and confidence intervals. Comparing sample means - One and two sample t- tests, Paired t- test, large sample tests, F- tests, comparing several sample-means- one way ANOVA. The Chi-square test of goodness of fit and independence of attributes.

SUGGESTED READINGS:

1. Field, A., & Miles, J. (2010). Discovering statistics using Microsoft Excel. Sage Publications Ltd.
2. Quirk, T. J., Saccuzzo, D. P., & Wilson, L. R. (2015). Statistics for business and economics: Microsoft Excel manual (13th ed.). Pearson.
3. Nelson, M. R., & Crouch, G. I. (2016). Business analytics using Excel. Cengage Learning.
4. Albright, S. C., Winston, W. L., & Zappe, C. J. (2016). Data analysis and decision making with Microsoft Excel (5th ed.). Cengage Learning.
5. Triola, M. F. (2017). Elementary statistics using Excel (6th ed.). Pearson.
6. Siegel, A. F., & Shim, J. K. (2017). Schaum's outline of statistics for business and economics: Including Microsoft Excel. McGraw-Hill Education.
7. Levine, D. M., Stephan, D. F., & Krehbiel, T. C. (2018). Statistics for managers using Microsoft Excel (8th ed.). Pearson.
8. Kvanli, A. H., Pavur, R. J., & Guynes, C. S. (2019). Introduction to business statistics: A Microsoft Excel manual (8th ed.). Pearson.
9. Anderson, D. R., Sweeney, D. J., & Williams, T. A. (2019). Statistics for business & economics (14th ed.). Cengage Learning.
10. Black, K. N., & Asay, B. (2019). Microsoft Excel 2019 data analysis and business modeling (6th ed.). Microsoft Press.

STA 002 SEC
Data Analysis Using IBM SPSS™
Credit 3 (0+0+3)

Course Learning Objective:
The objective of this course is to:
- Introduce students to Statistical Packages for Social Sciences (SPSS).
- Understand data entry in SPSS.
- Understand basic statistical calculation using SPSS.

Course Learning Outcomes:
After completion of the course, students will be able to:
- Identify, create and manipulate different types of variables in SPSS data editor.
- Import and export SPSS data files.
- Visually represent variables using SPSS.
- Characterize a data set using different descriptive statistics.
- Use different statistical tests to verify hypothesis about population parameters.

Contents (Practical): (Credit: 2)
Unit I (Lectures: 12)
Introduction to SPSS. Basic idea: The Data Editor, creating variables and Entering data, Types of variables, assigning values to the variables, Selecting and sorting Cases, Splitting and Merging Files, Computing and Recoding variables.

Unit II (Lectures: 12)
Visualization: Diagrammatic and Graphic representation of data (using Pie Diagram, Bar Diagram, Line Diagram and Histogram).

Unit III (Lectures: 12)
Summarizing data: Frequency distribution, Tables (Cross tables and contingency tables). Measures of location: Mean, Median, Mode and Partition values; Geometric Mean and Harmonic Mean. Measures of Dispersion: Range, Mean Deviation, Quartile Deviation, Standard Deviation; Skewness and Kurtosis, Bivariate Data: Scatter plots, Karl Pearson's Coefficient of Correlation, Spearman's Rank Correlation and lines of regression.

Unit IV (Lectures: 12)
Testing Hypothesis: Understanding of hypothesis testing, computation of p-values and confidence intervals. Comparing sample means - One and two sample t- tests, Paired t-test, large sample tests, F- tests, comparing several sample means- one way ANOVA. The Chi-square test of goodness of fit and independence of attributes.

SUGGESTED READINGS:

1. Field, A. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). Sage Publications Ltd.
2. Pallant, J. (2016). SPSS survival manual: A step by step guide to data analysis using IBM SPSS (6th ed.). Open University Press.
3. Tabachnick, B. G., & Fidell, L. S. (2019). Using multivariate statistics (7th ed.). Pearson.
4. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage Learning.
5. Stevens, J. P. (2018). Applied multivariate statistics for the social sciences (6th ed.). Routledge.
6. Warner, R. M. (2013). Applied statistics: From bivariate through multivariate techniques (2nd ed.). Sage Publications, Inc.
7. Kim, J. O., & Mueller, C. W. (1978). Factor analysis: Statistical methods and practical issues. Sage Publications, Inc.
8. IBM Corporation. (2020). IBM SPSS statistics 27 documentation. IBM Corporation.

STA 003 SEC
Introduction to Statistical Computing Using R
Credit 3 (0+0+3)

Course Learning Objective:

The objective of this course is to:
- Introduce students to the possibility of using computer programming to solve statistical problems.
- Introduce students to R programming and its usefulness in statistical calculation.

Course Learning Outcomes:

After completion of the course, students will be able to:
- Install and operate R GUI and R Studio IDE.
- Write, store and reuse R scripts.
- Install packages.
- Create vectors, matrices and data frames.
- Plot different graphs and diagrams.
- Calculate basic descriptive statistics.

Contents (Practical): (Credit: 3)

Unit I (Lectures: 12)
Introduction: About R programming language, Features of R, R as a calculator, using the command-line interface of R; About R Studio, Features of R Studio, Install packages.
Features of an R script, Creating and saving an R script from the user interface (UI) of R Studio, Shortcut keys to create an R script, using auto-completion of commands, running an entire script, running a block of a script, adding comments, Loading one script into another script. Working directory in R using *getwd()* function, Setting a working directory using *setwd()* function, Reading and storing a CSV file in R using *read.csv()* function, *view()* function; Methods of data input, Data accessing or indexing, Some useful built in functions.

Unit II (Lectures: 12)
Data Import and Export: Storing information in vectors, constructing a data frame using vectors, plotting one vector of a data frame vs. another one, adding a vector to a data frame, saving a data frame into a CSV file, Preventing the writing of row numbers into the CSV file, Changing the contents of a CSV file through a text editor, loading a CSV file into a data frame, Accessing the data sets that come with R

Unit III (Lectures: 12)

Descriptive statistics: Measures of central tendency, measures of dispersion, Measures of skewness and Kurtosis, Simple correlation and regression.

Graphics with R: Basics of graphs in R, Drawing and customizing Histogram, Bar charts, Scatter plot and Box plot in R.

Unit IV (Lectures: 12)

Data Frames: Converting a data frame into a matrix, creating a matrix with known data, Basic matrix operations: adding, subtraction, multiplication, transpose, determinant, inversion, Calculating the sum of elements in a matrix using for loop, sum of elements in a matrix using the sum function, Calculating the time elapsed in an operation, finding out the sum of rows/columns of a matrix, Adding a new column or row to an existing data-frame, *cbind()* and *rbind()* functions.

SUGGESTED READINGS:

1. Dalgaard, P. (2002). Introductory statistics with R (2nd ed.). Springer.
2. Fox, J. (2002). An R and S-Plus companion to applied regression. Sage Publications Inc.
3. Crawley, M. J. (2005). Statistics: An introduction using R. Wiley.
4. Zuur, A. F., Ieno, E. N., & Smith, G. M. (2007). Analysing ecological data (1st ed.). Springer.
5. Faraway, J. J. (2009). Practical regression and ANOVA using R. Chapman and Hall/CRC.
6. Gelman, A., & Hill, J. (2007). Data analysis using regression and multilevel/hierarchical models. Cambridge University Press.
7. Wickham, H. (2016). ggplot2: Elegant graphics for data analysis. Springer.
8. Wickham, H., & Grolemund, G. (2017). R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media, Inc.
9. Kuhn, M. (2019). Feature engineering and selection: A practical approach for predictive models. Chapman and Hall/CRC.
10. Peng, R. D. (2010). Exploratory data analysis with R. Springer.
11. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning: With applications in R. Springer.

MULTI-DISCIPLINARY ELECTIVE
STA 103 MDE / STA 203 MDE
Introduction to Statistics
Credit 3 (3+0+0)

Course Learning Objective:
The objective of this course is to –
- Introduce students to various types of statistical data, descriptive statistics, and interpretation of the outcomes.
- Introduce the concept of probability and some basic probability distributions.
- Introduce the concept of sampling from a population and how samples can be drawn from a population using various methods.

Course Learning Outcomes:
After completing this course, the students should have developed a clear understanding of the following:
- Different types of statistical data, how to distinguish and record them.
- The calculation procedure of different measures of central tendency, dispersion and bivariate relationship.
- Probability, different terms associated with probability and calculation of the probability of an event. Standard probability distributions.
- Sampling from a population, why we need sampling, what are the limitations of sampling and what are the different methods of drawing a sample.

Unit I (Lectures: 8)
Introduction to Statistics: Definition, origin and development of statistics. The idea of statistical population and sample. Types of data – primary, secondary, qualitative, quantitative. Collection of data, Preparation of questionnaire and schedule. Classification and tabulation, frequency distribution, diagrams and graphs.

UNIT II (Lecture:14)
Descriptive Statistics: Calculation of mean, median, and mode for grouped and ungrouped data. Partition values – calculation of quartile, decile and percentile for grouped data. Measures of dispersion – calculation of range, mean deviation, standard deviation, and coefficient of variation for grouped and ungrouped data.
Bivariate data – scatter diagram, Karl Pearson's coefficient of correlation. The idea of linear regression.

Unit II (Lectures: 14)
Probability Theory: Basic concepts of Random experiment, Sample point, Sample space, Events and types of events, Union and intersection of events. Probability of an event. Classical, empirical and axiomatic definitions of probability. Addition and multiplication

rules of probability. The idea of conditional probability. Dependent and independent events.

Random variable; Discrete and continuous distribution of a random variable, p.m.f. and p.d.f., distribution function. Mathematical expectation of a random variable. Introduction to probability distribution – Binomial, Poisson, Normal.

Unit III (Lectures: 12)
Sample Survey: Sample survey and complete enumeration. Basic principles of sample survey. Errors in a survey. Sampling and non-sampling errors. Advantage of sample survey over complete enumeration. Pilot survey. Types of sampling – probability and non-probability. Simple random sampling (SRS) with and without replacement - method of selection of SRS by making use of random number tables. Limitations of SRS. Idea of stratified random, systematic, and cluster sampling.

SUGGESTED READINGS:

1. Agrawal, R. P. (2013). Basic Statistics. New Age International.
2. Gupta, S. P., & Kapoor, V. K. (2013). Fundamentals of Mathematical Statistics. Sultan Chand & Sons.
3. Bhardwaj, R. C. (2013). An Introduction to Probability and Statistics. New Age International.
4. Khurshid, A., & Siddiquee, A. (2013). Statistical Inference: Theory and Practice. Wiley.
5. Moodithaya, M. S., & Samuel, J. (2016). Probability and Statistics: An Undergraduate Course. Springer.
6. Das, N. G., & Das, U. (2016). A First Course in Probability and Statistics with Applications. Wiley.
7. Jayaraman, K., Jain, S., & Sharma, K. (2015). Probability and Statistics for Engineers. Wiley.
8. Rao, V. S. (2015). Applied Statistics for Engineers and Scientists. Springer.

STA 304 MDE
Introduction to Applied Statistics
Credit 3 (3+0+0)

Course Learning Objective:
This course aims to provide students with a comprehensive understanding of index numbers, time series, vital statistics, and the official statistical system in India. The course will equip students with the knowledge and skills required to construct and interpret index numbers, analyse time series data, calculate vital rates and ratios, and understand the role of various government organizations in producing official statistics.

Course Learning Outcomes:
By the end of this course, students should be able to:
- Understand the concept of index numbers and the different types of index numbers.
- Construct index number using various methods, such as Laspeyre's, Paasche's, Marshall-Edgeworth, and Fisher's.
- Construct and use consumer price index numbers to analyse inflation and price changes.
- Define time series and its components.
- Determine trend using graphical, semi-average, moving average, and least square methods.
- Calculate vital rates and ratios, such as crude, general, age-specific, and total fertility rates, as well as gross and net reproduction rates and crude, age-specific, and standardized mortality rates.
- Understand the basic concept of life tables, migration, and nuptiality in vital statistics.
- Explain the role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), and National Sample Survey Office (NSSO) in producing official statistics in India.

Unit I (Lectures:12)
Index Numbers: Idea and uses of Index numbers, simple and weighted index numbers, Laspeyre's, Paasche's, Marshall – Edgeworth and Fisher's index numbers. Tests for a good index number. Construction and use of consumer price index number.

Unit II (Lectures: 12)
Time Series: Meaning, Components and Uses of time series, Determination of trend by the graphical, semi-average, moving average, and least square methods.

Unit III (Lectures: 16)

Vital Statistics: Vital rates and ratios, Fertility rates – crude, general, age specific and total. Reproduction rates – gross and net. Mortality rates – crude, age-specific, standardised. Idea of – life tables, migration, and nuptiality

Unit IV (Lectures: 8)

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

SUGGESTED READINGS:

1. Gupta, S. P., & Kapoor, V. K. (2017). Fundamentals of applied statistics (5th ed.). Sultan Chand & Sons.
2. Goon, S.C., Gupta, M.K., & Dasgupta, B. (2019). Fundamentals of Statistics, Volume 2. World Scientific Publishing.
3. Mukhopadhyay, P. (2014). Applied Statistics. Boca Raton: CRC Press.
4. Nath, D. C., & Pal, S. K. (2013). Introduction to vital statistics. New Delhi: PHI Learning Private Limited.
5. Nair, K. R. G. (2014). Demography and vital statistics. New Delhi: Sterling Publishers Private Limited.
6. Karmakar, S. (2013). Index numbers: A guide to practice. New Delhi: PHI Learning Private Limited.
7. Sengupta, S., & Mondal, S. (2018). Official statistics: An introduction. New Delhi: Sage Publications India Pvt Ltd.