ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21

Year	Semester	Paper	Subject	IA	EA	Total
1	I	I	Descriptive Statistics	25	75	100
	II	II	Probability Theory and Distributions	25	75	100
2	III	III	Statistical Inference	25	75	100
	IV	IV	Sampling Techniques and Design of Experiments	25	75	100
		V	Applied Statistics	25	75	100

OBJECTIVE OF THE COURSE

Statistics is a key to success in the field of science and technology. Today, the students need a thorough knowledge of fundamental basic principles, methods, results and a clear perception of the power of statistical ideas and tools to use them effectively in modeling, interpreting and solving the real life problems. Statistics plays an important role in the context of globalization of Indian economy, modern technology, computer science and information technology.

The main objectives of the course are

- To build the basis for promoting theoretical and application aspects of statistics.

- To underline the statistics as a science of decision making in the real life problems with the description of uncertainty.

- To emphasize the relevance of statistical tools and techniques of analysis in the study of inter-disciplinary sciences.

- To acquaint students with various statistical methods and their applications in different fields.

- To cultivate statistical thinking among students.

- To develop skills in handling complex problems in data analysis and research design.

- To prepare students for future courses having quantitative components.

This course is aimed at preparing the students to hope with the latest developments and compete with students from other universities and put them on the right track.

Paper Wise Objectives

PAPER-I: Descriptive Statistics
- The objective of this paper is to throw light on the role of statistics in different fields with special reference to business and economics.
- It gives the students to review good practice in presentation and the format most applicable to their own data.
- The measures of central tendency or averages reduce the data to a single value which is highly useful for making comparative studies.
- The measures of dispersion throw light on reliability of average and control of variability
- The concept of Correlation and Linear Regression deals with studying the linear relationship between two or more variables, which is needed to analyze the real life problems.
- The attributes gives an idea that how to deal with qualitative data.

PAPER-II: Probability Theory and Distributions
- This paper deals with the situation where there is uncertainty and how to measure that uncertainty by defining the probability, random variable and mathematical expectation which are essential in all research areas.
- This paper gives an idea of using various standard theoretical distributions, their chief characteristics and applications in analyzing any data.

PAPER-III:Statistical Inference
- This paper deals with standard sampling distributions like Chi Square, t and F and their characteristics and applications.
- This paper deals with the different techniques of point estimation for estimating the parameter values of population and interval estimation for population parameters.
- In this paper, various topics of Inferential Statistics such as interval estimation,Testing of Hypothesis, large sample tests (Z-test), small sample tests (t-test, F-test, chi-square test) and non-parametric tests are dealt with. These techniques play an important role in many fields like pharmaceutical, agricultural, medical etc.

PAPER-IV: Sampling Techniques and Design of Experiments
- The sampling techniques deals with the ways and methods that should be used to draw samples to obtain the optimum results, i.e., the maximum information about the characteristics of the population with the available sources at our disposal in terms of time, money and manpower to obtain the best possible estimates of the population parameters
- This paper throw light on understanding the variability between group and within group through Analysis of Variance
- This gives an idea of logical construction of Experimental Design and applications of these designs now days in various research areas.
- Factorial designs allow researchers to look at how multiple factors affect a dependent variable, both independently and together.

PAPER-V: Applied Statistics
- This paper deals the time series on simple description methods of data, explains the variation, forecasting the future values, control procedures.
- It gives an idea of using index numbers in a range of practical situations, limitations and uses
- The vital statistics enlighten the students in obtaining different mortality, fertility rates thus obtaining the population growth rates and construction and use of life tables in actuarial science.

ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21
Semester – I (CBCS With Maths Combination Common to BA/BSc)
Paper - I: Descriptive Statistics

UNIT-I

Introduction to Statistics: Importance of Statistics. Scope of Statistics in different fields. Concepts of primary and secondary data. Diagrammatic and graphical representation of data: Histogram, frequency polygon, Ogives, Pie. Measures of Central Tendency: Mean, Median, Mode, Geometric Mean and Harmonic Mean. Median and Mode through graph.

UNIT-II

Measures of Dispersion: Range, Quartile Deviation, Mean Deviation and Standard Deviation, Variance. Central and Non-Central moments and their interrelationship. Sheppard's correction for moments. Skewness and kurtosis.

UNIT-III

Curve fitting: Bi- variate data, Principle of least squares, fitting of degree polynomial. Fitting of straight line, Fitting of Second degree polynomial or parabola, Fitting of power curve and exponential curves.

Correlation: Meaning, Types of Correlation, Measures of Correlation: Scatter diagram, Karl Pearson's Coefficient of Correlation, Rank Correlation Coefficient (with and without ties), Bi-variate frequency distribution, correlation coefficient for bi-variate data and simple problems. Concept of multiple and partial correlation coefficients (three variables only) and properties

UNIT-IV

Regression : Concept of Regression, Linear Regression: Regression lines, Regression coefficients and it's properties, Regressions lines for bi-variate data and simple problems. Correlation vs regression.

UNIT-V

Attributes : Notations, Class, Order of class frequencies, Ultimate class frequencies, Consistency of data, Conditions for consistency of data for 2 and 3 attributes only , Independence of attributes , Association of attributes and its measures, Relationship between association and colligation of attributes, Contingencytable: Square contingency**,** Mean square contingency, Coefficient of mean square contingency, Tschuprow's coefficient of contingency.

Text Books:
1. V.K.Kapoor and S.C.Gupta: Fundamentals of MathematicalStatistics,Sultan   Chand & Sons, NewDelhi.
2 BA/BSc I year statistics - descriptive statistics, probability distribution - Telugu Academy - Dr M.JaganmohanRao,DrN.Srinivasa Rao, Dr P.Tirupathi Rao, Smt.D.Vijayalakshmi.
3. K.V.S. Sarma: Statistics Made Simple: Do it yourself on PC. PHI

Reference books:

1. Willam Feller: Introduction to Probability theory and its applications. Volume –I,Wiley
2. Goon AM, Gupta MK, Das Gupta B : Fundamentals of Statistics , Vol-I, the World Press Pvt.Ltd.,Kolakota.
3. Hoel P.G: Introduction to mathematical statistics, Asia Publishinghouse.
4. M. JaganMohan Rao and Papa Rao: A Text book of StatisticsPaper-I.
5. Sanjay Arora and Bansi Lal: New Mathematical Statistics: Satya Prakashan , NewDelhi

Credits 2

Practicals - Paper – I

1. Graphical presentation of data (Histogram, frequency polygon,Ogives).
2. Diagrammatic presentation of data (Bar andPie).
3. Computation of measures of central tendency(Mean, Median andMode)
4. Computation of measures of dispersion(Q.D, M.D andS.D)
5. Computation of non-central, central moments, β_1 and β_2 for ungroupeddata.
6. Computation of non-central, central moments, β_1 and β_2 and Sheppard's corrections for groupeddata.
7. Computation of Karl Pearson's coefficients of Skewness and Bowley's coefficients ofSkewness.
8. Fitting of straight line by the method of leastsquares
9. Fitting of parabola by the method of leastsquares
10. Fitting of power curve of the type by the method of leastsquares.
11. Fitting of exponential curve of the type and by the method of leastsquares.
12. Computation of correlation coefficient and regression lines for ungroupeddata
13. Computation of correlation coefficient, forming regression lines for groupeddata
14. Computation of Yule's coefficient ofassociation
15. Computation of Pearson's, Tcherprows coefficient ofcontingency

Note: Training shall be on establishing formulae in Excel cells and derive the results. The excel output shall be exported to MS word for writing inference.

Course Learning Outcomes
Students will acquire
1) knowledge of Statistics and its scope and importance in various areas such as Medical, Engineering, Agricultural and Social Sciences etc.
2) knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion etc.
3) knowledge of other types of data reflecting quality characteristics including concepts of independence and association between two attributes,
4) insights into preliminary exploration of different types of data.
5) Knowledge of correlation, regression analysis, regression diagnostics, partial and multiple correlations.

ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21
Semester – II (CBCS With Maths Combination Common to BA/BSc)
Paper - II: **Probability Theory and Distributions**

UNIT-I

Introduction to Probability: Basic Concepts of Probability, random experiments, trial, outcome, sample space, event, mutually exclusive and exhaustive events, equally likely and favourable outcomes. Mathematical, Statistical, axiomatic definitions of probability. Conditional Probability and independence of events, Addition and multiplication theorems of probability for 2 and for n events. Boole's inequality and Baye's theorem and its applications in real life problems.

UNIT-II

Random variable: Definition of random variable, discrete and continuous random variables, functions of random variable. Probability mass function. Probability density function, Distribution function and its properties. For given pmf, pdf calculation of moments, coefficient of skewness and kurtosis. Bivariate random variable - meaning, joint, marginal and conditional Distributions, independence of random variables and simple problems.

UNIT- III

Mathematical expectation : Mathematical expectation of a random variable and function of a random variable. Moments and covariance using mathematical expectation with examples. Addition and Multiplication theorems on expectation. Definitions of M.G.F, C.G.F, P.G.F, C.F and their properties. Chebyshev and Cauchy - Schwartz inequalities.

UNIT-IV

Discrete Distributions: Binomial, Poisson, Negative Binomial, Geometric distributions: Definitions, means, variances, M.G.F, C.F, C.G.F, P.G.F, additive property if exists. Possion approximation to Binomial distribution. Hyper-geometric distribution: Defination, mean and variance.

UNIT - V

Continuous Distributions: Rectangular, Exponential, Gamma, Beta Distributions: mean , variance, M.G.F, C.G.F, C.F. **Normal Distribution**: Definition, Importance, Properties, M.G.F, CF, additive property.

Text Books:
1. V.K.Kapoor and S.C.Gupta: Fundamentals of MathematicalStatistics,Sultan   Chand & Sons, NewDelhi.
2 BA/BSc I year statistics - descriptive statistics, probability distribution - Telugu Academy - Dr M.JaganmohanRao,DrN.Srinivasa Rao, Dr P.Tirupathi Rao, Smt.D.Vijayalakshmi.
3. K.V.S. Sarma: Statistics Made Simple: Do it yourself on PC. PHI

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3. Hoel P.G: Introduction to mathematical statistics, Asia Publishinghouse.
4. M. JaganMohan Rao and Papa Rao: A Text book of StatisticsPaper-I.
5. Sanjay Arora and Bansi Lal: New Mathematical Statistics: Satya Prakashan , NewDelhi
6. Hogg Tanis Rao: Probability and Statistical Inference. 7th edition.Pearson.

Credits 2

Practicals Paper – II

1. Fitting of Binomial distribution – Directmethod.
2. Fitting of binomial distribution – Recurrence relationMethod.
3. Fitting of Poisson distribution – Directmethod.
4. Fitting of Poisson distribution - Recurrence relationMethod.
5. Fitting of Negative Binomialdistribution.
6. Fitting of Geometricdistribution.
7. Fitting of Normal distribution – Areasmethod.
8. Fitting of Normal distribution – Ordinatesmethod.
9. Fitting of Exponentialdistribution.

Note: Training shall be on establishing formulae in Excel cells and derive the results. The excel output shall be exported to MS word for writing inference.

Course Learning Outcomes
Students will acquire
1) ability to distinguish between random and non-random experiments,
2) knowledge to conceptualize the probabilities of events including frequentist and axiomatic approach. Simultaneously, they will learn the notion of conditional probability including the concept of Bayes' Theorem,
3) knowledge related to concept of discrete and continuous random variables and their probability distributions including expectation and moments,
4) knowledge of important discrete and continuous distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric, normal, uniform, exponential, beta and gamma distributions,
(e) acumen to apply standard discrete and continuous probability distributions to different situations.

ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21
Semester – III (CBCS With Maths Combination Common to BA/BSc)
Paper - III: Statistical Inference

UNIT-I

Concepts: Population, Sample, Parameter, statistic, Sampling distribution, Standard error. convergence in probability and convergence in distribution, law of large numbers, central limit theorem (statements only). Student's t- distribution, F – Distribution, χ^2-Distribution: Definitions, properties and their applications.

UNIT-II

Theory of estimation: Estimation of a parameter, criteria of a good estimator – unbiasedness, consistency, efficiency, &sufficiency and. Statement of Neyman's factorization theorem. Estimation of parameters by the method of moments and maximum likelihood (M.L), properties of MLE's. Binomial, Poisson &Normal Population parameters estimate by MLE method. Confidence Intervals.

UNIT-III

Testing of Hypothesis: Concepts of statistical hypotheses, null and alternative hypothesis, critical region, two types of errors, level of significance and power of a test. One and two tailed tests. Neyman-Pearson's lemma. Examples in case of Binomial, Poisson, Exponential and Normal distributions.

UNIT – IV

Large sample Tests:large sample test for single mean and difference of two means, confidence intervals for mean(s). Large sample test for single proportion, difference of proportions. standard deviation(s) and correlation coefficient(s**).**

SmallSampletests:t-testforsinglemean,differenceofmeansandpairedt-test.χ2-testforgoodness of fit and independence of attributes. F-test for equality ofvariances.

UNIT – V

Non-parametric tests- their advantages and disadvantages, comparison with parametric tests. Measurement scale- nominal, ordinal, interval and ratio. One sample runs test, sign test and Wilcoxon-signed rank tests (single and paired samples). Two independent sample tests: Median test, Wilcoxon – Mann-Whitney U test, Wald Wolfowitz's runs test**.**

TEXT BOOKS
   1. BA/BSc II year statistics - statistical methods and inference - Telugu Academy by
   A.Mohanrao, N.Srinivasa Rao, Dr R.Sudhakar Reddy, Dr T.C. RavichandraKumar.
   2. K.V.S. Sarma: Statistics Made Simple: Do it yourself on PC.PHI.

REFERENCE BOOKS:
   1. Fundamentals of Mathematics statistics : VK Kapoor and SCGuptha.
   2. Outlines of statistics, Vol II : Goon Guptha, M.K.Guptha, Das GupthaB.

   3. Introduction to Mathematical Statistics :HoelP.G.

   4. Hogg Tanis Rao: Probability and Statistical Inference. 7th edition.Pearson.

                                                                    Credits: 2

Practicals - Paper –III
1. Large sample test for singlemean
2. Large sample test for difference ofmeans
3. Large sample test for singleproportion
4. Large sample test for difference ofproportions
5. Large sample test for difference of standarddeviations
6. Large sample test for correlationcoefficient
7. Small sample test for singlemean
8. Small sample test for difference ofmeans
9. Small sample test for correlationcoefficient
10. Paired t-test(pairedsamples).
11. Small sample test for single variance($\chi 2$ - test)
12. Small sample test for difference ofvariances(F-test)
13. $\chi 2$ - test for goodness of fit and independence ofattributes
14. Nonparametric tests for single sample(run test, sign test and Wilcoxon signed ranktest)
15. Nonparametric tests for related samples (sign test and Wilcoxon signed ranktest)
16. Nonparametric tests for two independent samples (Median test, Wilcoxon –Mann- Whitney - U test,
    Wald - Wolfowitz' s runstest)

Note: Training shall be on establishing formulae in Excel cells and deriving the results. The excel output
shall be exported to MS Word for writinginferences.

   Course Learning Outcomes
   The students will acquire
   1) Concept of law large numbers and their uses
   2) Concept of central limit theorem and its uses in statistics
   3) concept of random sample from a distribution, sampling distribution of a statistic, standard
      error of important estimates such as mean and proportions,
   4) knowledge about important inferential aspects such as point estimation, test of hypotheses
      and associated concepts,
   5) knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,
   6) concept about non-parametric method and some important non-parametric tests.

ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21
Semester – IV (CBCS With Maths Combination Common to BA/BSc)
<u>Paper IV: Sampling Techniques and Designs of Experiments</u>

UNIT I
Simple Random Sampling (with and without replacement): Notations and terminology, various probabilities of selection. Random numbers tables and its uses. Methods of selecting simple random sample, lottery method, method based on random numbers. Estimates of population total, mean and their variances and standard errors, determination of sample size, simple random sampling of attributes.

UNIT II
Stratified random sampling: Stratified random sampling, Advantages and Disadvantages of Stratified Random sampling, Estimation of population mean, and its variance. Stratified random sampling with proportional and optimum allocations. Comparison between proportional and optimum allocations with SRSWOR.

Systematic sampling: Systematic sampling definition when $N = nk$ and merits and demerits of systematic sampling - estimate of mean and its variance. Comparison of systematic sampling with Stratified and SRSWOR.

UNIT III
Analysis of variance : Analysis of variance(ANOVA) –Definition and assumptions. One-way with equal and unequal classification, Two way classification.

Design of Experiments: Definition, Principles of design of experiments, CRD: Layout, advantages and disadvantage and Statistical analysis of Completely Randomized Design(C.R.D).

UNIT IV
Randomized Block Design (R.B.D) and Latin Square Design (L.S.D) with their layouts and Analysis, MissingplottechniqueinRBDandLSD.EfficiencyRBDoverCRD,EfficiencyofLSDoverRBDand CRD.

UNIT V
Factorial experiments – Main effects and interaction effects of 2^2 and 2^3 factorial experiments and their Statistical analysis. Yates procedure to find factorial effecttotals.

Text Books:

1. Telugu AcademyBA/BSc III year paper - III Statistics - applied statistics - Telugu

   academy by Prof.K.Srinivasa Rao, Dr D.Giri. Dr A.Anand, Dr V.PapaiahSastry.

2. K.V.S. Sarma: Statistics Made Simple: Do it yourself on PC.PHI.

Reference Books:
1. Fundamentals of applied statistics : VK Kapoor and SCGupta.
2. Indian Official statistics - MR Saluja.
3. Anuvarthita SankyakaSastram - TeluguAcademy.

Credits: 2

Practicals - Paper –IV

Sampling Techniques:

Estimation of population mean and its variance by
1. Simple random sampling with and without replacement. Comparison between SRSWRand SRSWOR.
2. Stratified random sampling with proportional and optimum allocations. Comparison between proportional and optimum allocations withSRSWOR.
3. Systematic sampling with N=nk. Comparison of systematic sampling with Stratified andSRSWOR.

Design of Experiments:
4. ANOVA - one - way classification with equal and unequal number ofobservations
5. ANOVA Two-way classification with equal number ofobservations.
6. Analysis ofCRD.
7. Analysis of RBD Comparison of relative efficiency of CRD withRBD
8. Estimation of single missing observation in RBD and itsanalysis
9. Analysis of LSD and efficiency of LSD over CRD andRBD
10. Estimation of single missing observation in LSD and itsanalysis
11. Analysis of 2^2 with RBD layout
12. Analysis of 2^3 with RBDlayout

Note: Training shall be on establishing formulae in Excel cells and deriving the results. The excel output shall be exported to MS Word for writinginferences.

Course Learning Outcomes

The students shall get
1) Introduced to various statistical sampling schemes such as simple, stratified and systematic sampling.
2) an idea of conducting the sample surveys and selecting appropriate sampling techniques,
3) Knowledge about comparing various sampling techniques.
4) carry out one way and two way Analysis of Variance,
5) understand the basic terms used in design of experiments,
6) use appropriate experimental designs to analyze the experimental data.

ANDHRA UNIVERSITY
B.A/B.Sc., STATISTICS (WM) CBCS REVISED SYLLABUS 2020-21
Semester – II to IV (CBCS With Maths Combination Common to BA/BSc)
<u>Paper V: Applied Statistics</u>

UNIT I
Time Series: Time Series and its components with illustrations, additive, multiplicativemodels. Trend: Estimation of trend by free hand curve method, method of semi averages.Determination of trend by least squares (Linear trend, parabolic trend only), moving averages method.

UNIT II
Seasonal Component: Determination of seasonal indices by simple averages method, ratio to moving average, Ratio to trend and Link relative methods, Deseasonalization.

UNIT III
Growth curves: Modified exponential curve, Logistic curve and Grompertz curve, fitting of growth curves by the method of three selected points and partial sums.Detrending. Effect of elimination of trend on other components of the time series

UNIT IV
Index numbers: Concept, construction, problems involved in the construction of index numbers, uses and limitations. Simple and weighted index numbers. Laspayer's, Paasche's and Fisher's index numbers, Criterion of a good index number, Fisher's ideal index numbers. Cost of living index number and wholesale price index number.

UNIT V
Vital Statistics: Introduction, definition and uses of vital statistics, sources of vital statistics.

Measures of different Mortality and Fertility rates, Measurement of population growth. Life tables: construction and uses of life tables.

Text Books:
1. Fundamentals of applied statistics : VK Kapoor and SCGupta.
2. BA/BSc III year paper - III Statistics - applied statistics - Telugu academy by prof.K.Srinivasa Rao, Dr D.Giri. Dr A.Anand, Dr V.PapaiahSastry.

Reference Books:
3. AnuvarthitaSankyakaSastram - TeluguAcademy.
4. Mukopadhyay, P (2011). Applied Statistics, 2nd ed. Revised reprint, Books and Allied Pvt. Ltd.
5. Brockwell, P.J. and Devis, R.A. (2003). Introduction to Time Series Analysis. Springer.
6. Chatfield, C. (2001). Time Series Forecasting., Chapman & Hall.
7. Srinivasan, K. (1998). Demographic Techniques and Applications. Sage Publications
8. Srivastava O.S. (1983). A Text Book of Demography. Vikas Publishing House

Practical Paper –V

Time Series:
1. Measurement of trend by method of moving averages(odd and evenperiod)
2. Measurement of trend by method of Least squares(linear andparabola)
3. Determination of seasonal indices by method simpleaverages
4. Determination of seasonal indices by method of Ratio to movingaverages
5. Determination of seasonal indices by method of Ratio totrend
6. Determination of seasonal indices by method of Linkrelatives

Index Numbers:
7. Computation of simple indexnumbers.
8. Computation of all weighted index numbers.
9. Computation of reversaltests.

Vital Statistics:
10. Computation of various Mortalityrates
11. Computation of various Fertilityrates
12. Computation of various Reproductionrates.
13. Construction of LifeTables

Note: Training shall be on establishing formulae in Excel cells and deriving the results. The excel output shall be exported to MS Word for writinginferences.

Course Learning Outcomes

After completion of this course, the students will know about
1) time series data, its applications to various fields and components of time series,
2) fitting and plotting of various growth curves such as modified exponential, Gompertz and logistic curve,
3) fitting of trend by Moving Average method,
4) measurement of Seasonal Indices by Ratio-to-Trend , Ratio-to-Moving Average and Link Relative methods,
5) Applications to real data by means of laboratory assignments.
6) Interpret and use a range of index numbers commonly used in the business sector
7) Perform calculations involving simple and weighted index numbers
8) Understand the basic structure of the consumer price index and perform calculations involving its use
9) Various data collection methods enabling to have a better insight in policy making, planning and systematic implementation,
10) Construction and implementation of life tables,
11) Population growth curves, population estimates and projections,
12) Real data implementation of various demographic concepts as outlined above through practical assignments.

REVISED UG SYLLABUS UNDER CBCS
(Implemented from Academic Year 2020-21)
PROGRAMME: FOUR YEAR B.Sc.,

Domain Subject: **STATISTICS**

Skill Enhancement Courses (SECs) for Semester V, from 2022-23
(Syllabus-Curriculum)

Structure of SECs for Semester – V
(To choose one pair from the three alternate pairs of SECs)

Univ. Code	Courses 6 & 7	Name of Course	Th. Hrs. / Week	IE Mar - ks	EE Mar - ks	Credits	Prac .Hrs ./ Wk	Mar - ks	Credits
	6A	Operations Research - I	3	25	75	3	3	50	2
	7A	Operations Research – II	3	25	75	3	3	50	2
OR									
	6B	Statistical Process and Quality Control	3	25	75	3	3	50	2
	7B	Computational Techniques and R Programming	3	25	75	3	3	50	2
OR									
	6C	Econometrics	3	25	75	3	3	50	2
	7C	Regression Analysis	3	25	75	3	3	50	2

Note-1: For Semester–V, for the domain subject Statistics, any one of the three pairs of SECs shall be chosen courses 6 and 7, i.e., 6A & 7A or 6B & 7B or 6C & 7C. The pair shall not be broken (ABC allotment is random, not on any priority basis).

Note-2: One of the main objectives of Skill Enhancement Courses (SEC) is to inculcate field skills related to the domain subject in students. The syllabus of SEC will be partially skill oriented. Hence, teachers shall also impart practical training to students on the field skills embedded in the syllabus citing related real field situations.

Facilities requirements for teaching the Skill Enhancement Courses in Statistics:

All the 6 courses mentioned as Skill Enhancement Courses require a computer lab with at least 20 desk top systems since each student has to practice the methodology and acquire skills in producing output. This requires various software packages both standard (like Microsoft Excel, TORA/ LINDO/LINGO for Operations Research,) as well as open-source packages (like R and Python) to handle statistical analysis. Once these facilities are provided and training given on these lines, the outgoing students will fit into skill oriented jobs like business data analysts and Data Scientists.

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 6A: **OPERATIONS RESEARCH - I**
(Skill Enhancement Course(Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Objective: The Objective of the paper is to introduce the basic concepts of Operational Research and linear programming to the students.

Learning Outcomes:
After learning this course, the student will be able
1. To know the scope of Operations Research
2. To link the OR techniques with business environment and life sciences
3. To convert real life problems into mathematical models
4. To find a solution to the problem in different cases
5. To inculcate logical thinking to find a solution to the problem

UNIT-I

Introduction of OR – Origin and development of OR – Nature and features of OR –Scientific Method in OR – Modeling in OR – Advantages and limitations of Models-General Solution methods of OR models – Applications of Operation Research. Linear programming problem (LPP) -Mathematical formulation of the problem - illustrations on Mathematical formulation of Linear programming of problem. Graphical solution of linear programming problems. Some exceptional cases - Alternative solutions, Unbounded solutions, non-existing feasible solutions by Graphical method.

UNIT-II

General linear programming Problem(GLP) – Definition   and Matrix form of GLP problem, Slack variable, Surplus variable, unrestricted Variable, Standard form of LPP and Canonical form of LPP. Definitions of Solution, Basic Solution, Degenerate Solution, Basic feasible Solution and Optimum Basic Feasible Solution. Introduction to Simplex method and Computational procedure of simplex algorithm. Solving LPP by Simplex method (Maximization case and Minimization case)

UNIT-III

Artificial variable technique - Big-M method and Two-phase simplex method, Degeneracy in LPP and method to resolve degeneracy. Alternative solution, Unbounded solution, Non existing feasible solution and Solution of simultaneous equations by Simplex method.

UNIT-IV

Duality in Linear Programming –Concept of duality -Definition of Primal and Dual Problems, General rules for converting any primal into its Dual, Economic interpretation of duality, Relation between the solution of Primal and Dual problem(statements only). Using duality to solve primal problem. Dual Simplex Method.

UNIT-V

Post Optimal Analysis- Changes in cost Vector **C**, Changes in the Requirement Vector **b**and changes in the Coefficient Matrix **A**. Structural Changes in a LPP.

Reference Books:

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co, Meerut.
2. Kanti Swarup, P.K.Gupta, Manmohn, Operations Research, Sultan Chand and sons, New Delhi.
3. J.K. Sharma, Operations Research and Application, Mc.Millan and Company, New Delhi.
4. GassS.I: Linear Programming. Mc Graw Hill.
5. HadlyG :Linear programming. Addison-Wesley.
6. Taha H.M: Operations Research: An Introduction : Mac Millan.

Practical/Lab to be performed on a computer using OR/Statistical packages

1. To solve Linear Programming Problem using Graphical Method with
   (i) Unbounded solution
   (ii) Infeasible solution
   (iii) Alternative or multiple solutions.
2. Solution of LPP with simplex method.
3. Problem solving using Charne's M - method.
4. Problem solving using Two Phase method.
5. Illustration of following special cases in LPP using Simplex method
   (i) Unrestricted variables
   (ii) Unbounded solution
   (iii) Infeasible solution
   (iv) Alternative or multiple solutions.
6. Problems based on Principle of Duality.
7. Problems based on Dual simplex method.
8. Problems based on Post Optimal Analysis.

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 7A: **OPERATIONS RESEARCH - II**
(Skill Enhancement Course(Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Objective: To enrich the knowledge of students with advanced techniques of linear programming problem along with real life applications.

Learning Outcomes:

After learning this course, the student will be able
1. To solve the problems in logistics
2. To find a solution for the problems having space constraints
3. To minimize the total elapsed time in an industry by efficient allocation of jobs to the suitable persons.
4. To find a solution for an adequate usage of human resources
5. To find the most plausible solutions in industries and agriculture when a random environment exists.

UNIT -I

Transportation Problem**-** Introduction, Mathematical formulation of Transportation problem. Definition of Initial Basic feasible solution of Transportation problem- North-West corner rule, Lowest cost entry method, Vogel's approximation method.   Method of finding optimal solution-MODI method(U-V method). Degeneracy in transportation problem, Resolution of degeneracy, Unbalanced transportation problem. Maximization TP. Transshipment Problem.

UNIT-II

Assignment Problem **-**Introduction, Mathematical formulation of Assignment problem, Reduction theorem (statement only), Hungarian Method for solving Assignment problem, Unbalanced Assignment problem. The Traveling salesman problem, Formulation of Traveling salesman problem as an Assignment problem and Solution procedure.

UNIT-III

Sequencing problem: Introduction and assumptions of sequencing problem, Sequencing of n jobs and one machine problem. Johnson's algorithm for n jobs and two machines problem- problems with n-jobs on two machines, Gantt chart, algorithm for n jobs on three machines problem-problems with n- jobs on three machines, algorithm for n jobs on m machines problem, problems with n-jobs on m-machines. Graphical method for two jobs on m– machines.

UNIT-IV

Network Scheduling: Basic Components of a network, nodes and arcs, events and activities–Rules of Network construction – Time calculations in networks - Critical Path method (CPM) and PERT.

UNIT –V

GameTheory:Two-personzero-sumgames.PureandMixedstrategies.Maxmin and Minimax Principles - Saddle point and its existence. Games without Saddle point-Mixed strategies. Solution of 2 x 2 rectangular games. Graphical method of solving 2 x n and m x 2 games. Dominance Property. Matrix oddment method for n x n games. Only formulation of Linear Programming Problem for m x n games.

Reference Books:

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co, Meerut.
2. Kanti Swarup, P.K.Gupta, Manmohn, Operations Research, Sultan Chand and sons, New Delhi.
3. J.K. Sharma, Operations Research and Application, Mc. Millan and Company, New Delhi.
4. Gass: Linear Programming. Mc Graw Hill.
5. Hadly :Linrar programming. Addison-Wesley.
6. Taha : Operations Research: An Introduction : Mac Millan.
7. Dr.NVS Raju; Operations Research, SMS education,

Practical/Lab to be performed on a computer using OR/Statistical packages

1. IBFS of transportation problem by using North- West corner rule, Matrix minimum method and VAM
2. Optimum solution to balanced and unbalanced transportation problems by MODI method (both maximization and minimization cases)
3. Solution of Assignment problem using Hungarian method (both maximization and minimization cases),
4. Solution of sequencing problem—processing of n jobs through two machines
5. Solution of sequencing problem- processing of n jobs through three machines
6. To perform Project scheduling of a given project (Deterministic case-CPM).
7. To perform Project scheduling of a given project (Probabilistic case-PERT).
8. Graphical method of solving for m x 2 and 2 x n games.
9. Solution of m x n games by dominance rule.
10. Solution of n x n games by using matrix oddment method.
11. Linear programming method for solving m x n games.

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 6B: **Statistical Process and Quality Control**
(Skill Enhancement Course(Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Course Objectives: To understand the concept of quality, process control and product control using control chart techniques and sampling inspection plan. To have an idea about quality management, quality circles, quality movement and standardizations for quality.

Learning Outcomes:
After learning this course, the student will be able
   1. To define 'quality' in a scientific way
   2. To differentiate between process control and product control
   3. To speak about quality awareness in industry
   4. To pave a path to an industry to meet the standards
   5. To effectively implement various plans to control the quality standards at various stages of an industry.

Unit I
Meaning of quality, concept of total quality management (TQM) and six-sigma, ISO, comparison between TQM and Six Sigma, Meaning and purpose of Statistical Quality Control (SQC), Seven Process Control Tools of Statistical Quality Control (SQC) (i) Histogram (ii) Check Sheet, (iii) Pareto Diagram (iv) Cause and effect diagram (CED), (v) Defect concentration diagram (vi) Scatter Diagram (vii) Control chart. (Only introduction of 7 tools is expected).

Unit II
Statistical basis of Shewhart control charts, use of control charts. Interpretation of control charts, Control limits, Natural tolerance limits and specification limits. Chance causes and assignable causes of variation, justification for the use of 3-sigma limits for normal distribution, Criteria for detecting lack of control situations:
(i) At least one point outside the control limits
(ii) A run of seven or more points above or below central line.

Unit III
Control charts for Variables: Introduction and Construction of $\bar{X}$ and R chart and Standard Deviation Chart when standards are specified and unspecified, corrective action if the process is out of statistical control.

Control charts for Attributes: Introduction and Construction of p chart, np chart, C Chart and U charts when standards are specified and unspecified, corrective action if the process is out of statistical control.

Unit IV

Acceptance Sampling for Attributes: Introduction, Concept of sampling inspection plan, Comparison between 100% inspection and sampling inspection. Procedures of acceptance sampling with rectification, Single sampling plan and double sampling plan.

Producer's risk and Consumer's risk, Operating characteristic (OC) curve, Acceptable Quality Level (AQL), Lot Tolerance Fraction Defective (LTFD) and Lot Tolerance Percent Defective (LTPD), Average Outgoing Quality (AOQ) and Average Outgoing Quality Limit (AOQL), AOQ curve, Average Sample Number (ASN), Average Total Inspection (ATI).

Unit V

Single Sampling Plan: Computation of probability of acceptance using Binomial and Poisson approximation, of AOQ and ATI. Graphical determination of AOQL, Determination of a single sampling plan by: a) lot quality approach b) average quality approach.

Double Sampling Plan: Evaluation of probability of acceptance using Poisson distribution, Structure of OC Curve, Derivation of AOQ, ASN and ATI (with complete inspection of second sample), Graphical determination of AOQL, Comparison of single sampling plan and double sample plan.

Text Books:

1. **Montgomery, D. C. (2008)**: Statistical Quality Control, 6thEdn., John Wiley, New York.
2. **Parimal Mukhopadhyay:** Applied Statistics, New Central Book Agency.
3. **Goon A.M., Gupta M.K. and Das Gupta B. (1986):** Fundamentals of Statistics, Vol. II, World Press, Calcutta.
4. **S.C. Gupta and V.K. Kapoor:** Fundamentals of Applied Statistics – Chand publications.

References:

1. **R.C. Gupta:** Statistical Quality Control.
2. **Duncan A.J. (1974):** Quality Control and Industrial Statistics, fourth edition D.B. Taraporewala Sons and Co. Pvt. Ltd., Mumbai.
3. **Grant, E. L. and Leavenworth (1980):** Statistical Quality Control, fifth edition, Mc-Graw Hill, New Delhi.

Practical/Lab to be performed on a computer using Statistical packages

1. Construction of $\bar{X}$ and R Charts.
2. Construction of $\bar{X}$ and σ Charts.
3. Construction of p Charts for fixed sample size.
4. Construction of p Charts for variable sample size.
5. Construction of np Charts.
6. Construction of C charts.
7. Construction of U charts.
8. Single sampling plan for attributes (OC Curve, Producer's and Consumer's risks, AOQ, AOQL, ATI).
9. Determination of single sampling plan by: a) lot quality approach b) average quality approach.
10. Double sampling plan for attributes (OC curve, AOQ, AOQL, ATI, ASN using Poisson distribution).

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 7B: **Computational Techniques and R Programming**
(Skill Enhancement Course (Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Course Objectives: To learn the statistical analysis with the help of the statistical software R
Learning Outcomes:
After learning this course the student will be able
1. Understand the basic functioning of a computer
2. Acquire skills in handling business and organizational data using Excel
3. Perform simple analytics using Excel
4. Understand the power of R programming language
5. Handle various statistical issues using R language

Unit I

Computer basics: Basic applications of computer, components of computer system, Central Processing Unit (CPU), input and output units, computer memory and mass storage devices. Programming languages and their applications. Concept of files and folders. Software and types of software. Operating System like Windows and Linux.

Unit II

Data processing using spreadsheets – Data entry and editing features in Excel, copy, paste, paste special options, sort and filter options, auto sum, steps of finding average and standard deviation of data using statistical functions. Matrix operations like transpose, multiply and inverse using Excel functions. Simple graphs like bar chart, line chart and pie chart in Excel. Exporting Excel output to word processers like MS-Word and slide presentations like Power Point.

Unit III

Scatter diagram, fitting of straight line, polynomial and power curves using Excel – Reading R-square value and equation from the graph. Predicting future values using 'forecast' and 'trend' functions.   Data Analysis Pak and its features.   Performing Student's t-test and one-way Analysis of Variance using Data Analysis Pak. P-value and its interpretation.

Unit IV

Programming with R: Introduction to R, Data types in R (numeric, logical, character, complex etc.), R objects: vector, matrix, array, list, data frame, factor, and time series. Arithmetic, logical and relational operators, explicit and implicit looping, functions and functional programming in R, Lexical scoping rules in R, benefits of Lexical scoping, other scoping rules, debugging facility in R. Few important mathematical, statistical and graphical functions in R.

Unit V

Descriptive Statistics with R software: Calculations with R software such as descriptive statistics, frequency distribution, Graphics and plots, statistical functions of central tendency, variation, skewness and kurtosis and illustration with examples.

Suggested Books

1. Chambers, J. (2008). Software for Data Analysis: Programming with R, Springer.
2. Crawley, M.J. (2017). The R Book, John Wiley & Sons.
3. Eckhouse, R.H. and Morris, L.R. (1975). Minicomputer Systems Organization, Programming and Applications, Prentice-Hall.
4. Matloff, N. (2011). The Art of R Programming, No Starch Press, Inc.
5. Peter N. (1986). Inside the IBM PC, Prentice-Hall Press.
6. Dr. Mark Gardener(2012): Beginning R The statistical Programming Languages, John Wiley & Sons.
7. K.V.S. Sarma (2010), Statistics Made Simple – Do it yourself on PC, 2nd Edition, Prentice Hall India
8. Sudha G. Purohit, SharadD.Gore, and ShailajaR.Deshmukh (2008), Statistics Using R, Narosa Publishing House, India.
9. Crawley, M.J. (2006). Statistics – An introduction using R. John Wiley London.
10. Purohit, S.G., Deshmukh, S.R. and Gore, S.D., (2015): Statistics using R, Alpha Science International.
11. Verzani, J., (2018): Using R for introductory statistics. CRC press.
12. Schumacker, R.E., (2014): Learning statistics using R. Sage Publications.
13. Michale J. Crawley (2009), THE R BOOK, John Wiley & Sons.

Practical/Lab to be performed on a computer using R Software
1. Construction of Bar Chart and Pie Chart using Excel
2. Fitting of straight-line using Excel
3. Calculating Matrix Inverse using Excel
4. One way ANOVA using Excel
5. Data visualization using R - frequency polygon, Ogives, Histogram.
6. Data visualization using R - simple and multiple bar diagram, pie chart.
7. Computation of Descriptive Statistics using R - Central Tendencies, Dispersions, Moments, Skewness and Kurtosis.
8. Computation of Karl Pearson's Coefficient of Correlation and Rank Correlation using R.
9. Construction of Control Charts for variables ($\bar{X}$, R and σ) charts using R.
10. Construction of Control Charts for attributes (p, np charts with fixed and varying sample sizes) using R.
11. Construction of Control Charts using R - C and U charts.

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 6C: **ECONOMETRICS**
(Skill Enhancement Course(Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Learning Outcomes:

The course on econometrics will primarily focus on the use of statistical modeling and the relevant analyses to economic data problems. After learning this course the student will be able understand

1. various important econometric models and relevant model building concepts in econometrics
2. general linear models and estimation of inherent model parameters
3. multicollinearity, its detection and consequences and related inferential aspects
4. some advanced concepts of generalised least squares estimation, autocorrelation, its consequences, detection and strategy for reducing autocorrelation,
5. heteroscedasticity and its inherent concepts including its consequences,
6. some inferential aspects on heteroscedasticity,
7. practical aspects and real data illustration of the related problems.

UNIT-I

Basic Econometrics: Nature of econometrics and economic data, concept of econometrics, steps in empirical economic analysis, econometric model, importance of measurement in economics, the structure of econometric data, cross section, pooled cross section, time series and paired data.

UNIT-II

Models and Estimations: Simple regression models- two variable linear regression model, assumptions and estimation of parameters. Gauss Markoff theorem, OLS estimations, partial and multiple correlations coefficients. The general linear model assumptions, estimation and properties of estimators, BLUEs.

UNIT- III

Heteroscedastic disturbances : Tests of significance of estimators, R square and ANOVA. Concepts and consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Specification error, Errors of measurement.

UNIT-IV

Multicollinearity: The concept of multicollinearity and its consequences on econometric models, detection of multicollinearity. Measure of Multicollinearity – Variance Inflation Factor (VIF) and tolerance, formula and interpretation. Methods of reducing the influence of multicollinearity.

UNIT - V

Autocorrelation: Disturbance term (u) in econometric models and its assumptions, autocorrelated disturbances and their consequences on the model parameters, Detecting the presence of autocorrelation – hypothesis tests for autocorrelation - Durbin Watson test and its interpretation.

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.

Practical/Lab to be performed on a computer using Statistical packages

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.

Course Code:

Four-year B.A./B.Sc.
Domain Subject: **Statistics**
Course 7C: **REGRESSION ANALYSIS**
(Skill Enhancement Course(Elective), 05 Credits
Max. Marks: Theory :100 + Practicals: 50

Learning Outcomes:

After learning this course the student will be able

1. To know about regression techniques, which are powerful tools in statistics,
2. To get an idea of Linear and Multiple Linear regression,
3. To learn about regression diagnostics, residual plots for visualization
4. To perform statistical tests of hypotheses on regression coefficients.
5. To study the structural stability of a regression model.
6. To learn the regression with qualitative independent and dependent variables by dummy variable technique.
7. To learn the selection of the best regression model.

Unit I

Simple Linear Regression: Simple Linear Regression Model. Least-Squares Estimation of the Parameters - Estimation of β_0 and β_1, Properties of the Least-Squares Estimators and the Fitted Regression Model. Hypothesis Testing on the Slope and Intercept -Use of t Tests, Testing Significance of Regression and Analysis of Variance

Unit II

Multiple Linear Regression: Multiple linear regression: Multiple Linear Regression Model. Estimation of model parameters: Least-Squares Estimation of the Regression Coefficients, Properties of the Least-Squares Estimators. Concept of residual, Residual plots. Test for Significance of Individual Regression Coefficients, and subsets of coefficients. Concept of coefficient of determination.

Unit III

Regressions with Qualitative Independent Variables: Use of dummy variables to handle categorical independent variables in regression. Estimation of model parameters with dummy variables - Testing the structural stability of regression models, comparing the slopes of two regression models. Multiple linear regression with interaction effects.

Unit-IV

Regressions with Qualitative Dependent Variables: Binary logistic regression with several independent variables, estimation of coefficients, evaluating the Odds Ratio (OR) and its interpretation. The concept of Piecewise linear regression, The Logit,Probit and Tobit models and their applications.

Unit – V

Best Model: Selecting 'Best' regression model. All possible regressions – R^2, Adjusted R^2, MS_{Res}, Mallow's statistic. Sequential selection of variables – criteria for including and eliminating a variable – forward selection, backward elimination and stepwise regression.

References:

1. Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining (2012), Introduction To Linear Regression Analysis, Fifth Edition, John Wiley & Sons
2. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis. 3rd Edition. John Wiley.
3. Hosmer, D. W., Lemeshow, S. and Sturdivant R.X. (2013). Applied Logistic Regression, Wiley Blackwell.
4. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2013). Introduction to Linear Regression Analysis. 5th Edition. Wiley.
5. Neter, J., Kutner, M. H., Nachtsheim, C.J. and Wasserman, W. (1996). Applied Linear Statistical Models, 4th Edition, Irwin USA.
6. Gujarati, D. and Sangeetha, S. (2007). Basic Econometrics, 4th Edition

Practical/Lab to be performed on a computer using Statistical packages

1. Least Squares estimates of slope and intercept
2. Plotting of two Regression Lines
3. Finding R-square value of Linear Models
4. Student's t-test for regression coefficient
5. ANOVA for Multiple Linear Regression model
6. Selecting best regression model by R^2
7. Selecting best regression model by Adjusted R^2
8. Selecting best regression model by MS_{Res}
9. Selecting best regression model by Mallow's statistic
10. Selecting best regression model by forward selection
11. Selecting best regression model by backward elimination.