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 WithMaths 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 - DrM.JaganmohanRao,DrN.SrinivasaRao, DrP.TirupathiRao, 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. JaganMohanRao and Papa Rao: A Text book of StatisticsPaper-I.
5. Sanjay Arora and BansiLal: New Mathematical Statistics: SatyaPrakashan , 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, $\Box 1$ and $\Box 2$ for ungroupeddata.
6. Computation of non-central, central moments, $\Box 1$ and $\Box 2$ 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 WithMaths 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 - DrM.JaganmohanRao,DrN.SrinivasaRao, DrP.TirupathiRao, 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

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3. Hoel P.G: Introduction to mathematical statistics, Asia Publishinghouse.

4. M. JaganMohanRao and Papa Rao: A Text book of StatisticsPaper-I.

5. Sanjay Arora and BansiLal: New Mathematical Statistics: SatyaPrakashan , NewDelhi

6. Hogg Tanis Rao: Probability and Statistical Inference. 7thedition.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 WithMaths 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.$\Box$2-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.SrinivasaRao, DrR.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, VolII : Goon Guptha, M.K.Guptha, Das GupthaB.
3. Introduction to Mathematical Statistics :HoelP.G.
4. Hogg Tanis Rao: Probability and Statistical Inference. 7thedition.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 WithMaths Combination Common to BA/BSc)
Paper IV: Sampling Techniques and Designs of Experiments

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.SrinivasaRao, DrD.Giri. DrA.Anand, DrV.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. AnuvarthitaSankyakaSastram - 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 WithMaths Combination Common to BA/BSc)

Paper V: Applied Statistics

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.SrinivasaRao, DrD.Giri. DrA.Anand, DrV.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

Credits: 2

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.

21)PROGRAMME:FOURYEARB.Sc.,

DomainSubject:STATISTICS

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

StructureofSECsforSemester–V
*(To chooseone pairfromthethree alternatepairsof
SECs)*

Univ. Code	Courses6 &7	NameofCourse	Th.Hrs./Week	IE Mar-ks	EE Mar-ks	Credits	Prac.Hrs./Wk	Mar-ks	Credits
	6A	OperationsResearch-I	3	25	75	3	3	50	2
	7A	OperationsResearch–II	3	25	75	3	3	50	2
OR									
	6B	StatisticalProcess andQualityControl	3	25	75	3	3	50	2
	7B	ComputationalTechniquesandRP rogramming	3	25	75	3	3	50	2
OR									
	6C	Econometrics	3	25	75	3	3	50	2
	7C	RegressionAnalysis	3	25	75	3	3	50	2

Note-1: For Semester–V, for the domain subject Statistics, any one of the three pairs of SECsshall be chosen courses 6 and 7, i.e., 6A & 7A or 6B & 7B or 6C & 7C. The pair shall not bebroken(ABC allotmentisrandom,notonanypriority basis).

Note-2: One of the main objectives of Skill Enhancement Courses (SEC) is to inculcate fieldskills related to the domain subject in students. The syllabus of SEC will be partially skilloriented. Hence, teachers shall alsoimpartpractical training to students on the field skillsembeddedinthesyllabuscitingrelatedrealfieldsituations.

FacilitiesrequirementsforteachingtheSkillEnhancementCoursesin Statistics:

All the 6 courses mentioned as Skill Enhancement Coursesrequire a computer labwith atleast 20 desk top systemssince each student has to practice the methodology and acquireskills inproducingoutput.This requires various software packages bothstandard(likeMicrosoft Excel, TORA/ LINDO/LINGO for Operations Research,) as well as open-sourcepackages (like R and Python) to handle statistical analysis.Once these facilities are providedand training given on these lines, the outgoing students will fit into skill oriented jobs likebusinessdataanalysts andDataScientist

Objective:TheObjectiveofthepaperistointroducethebasicconceptsofOperationalResearc handlinearprogrammingtothestudents.

LearningOutcomes:
Afterlearningthiscourse,thestudentwillbeable
1. Toknowthe scopeofOperationsResearch
2. TolinktheORtechniqueswithbusinessenvironmentandlifesciences
3. Toconvertreallifeproblemsinto mathematicalmodels
4. Tofindasolutiontotheproblemindifferentcases
5. Toinculcatelogicalthinkingtofindasolutiontotheproblem

UNIT-I

Introduction of OR – Origin and development of OR – Nature and features of OR – ScientificMethod in OR – Modeling in OR – Advantages and limitations of Models-General Solutionmethods of OR models – Applications of Operation Research. Linear programming problem(LPP) -Mathematical formulation of the problem -illustrations on Mathematical formulationof Linearprogrammingof problem.Graphical solution of linearprogrammingproblems.Some exceptional cases - Alternative solutions, Unbounded solutions, non-existing feasiblesolutionsbyGraphicalmethod.

UNIT-II

General linear programming Problem(GLP) – Definitionand Matrix form of GLP problem,Slack variable, Surplus variable, unrestricted Variable, Standard form of LPP and Canonicalform of LPP. Definitions of Solution, Basic Solution, Degenerate Solution, Basic feasibleSolutionandOptimumBasicFeasibleSolution.IntroductiontoSimplexmethodandComputationalprocedureofsimplexalgorithm.SolvingLPPbySimplexmethod(MaximizationcaseandMinimizationcase)

UNIT-III

Artificial variable technique - Big-M method and Two-phase simplex method, Degeneracy inLPPandmethodtoresolvedegeneracy.Alternativesolution,Unboundedsolution,Nonexistingfeasiblesolutionand Solutionofsimultaneousequationsbysimplexmethod.

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 tosolve primalproblem.DualSimplexMethod.

UNIT-V

PostOptimalAnalysis-ChangesincostVector**C**,ChangesintheRequirementVector**b**andchangesintheCoefficient Matrix **A**.Structural Changesina LPP

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ReferenceBooks:

1. S.D.Sharma,OperationsResearch,KedarNathRamNath&Co,Meerut.
2. KantiSwarup,P.K.Gupta,Manmohn,OperationsResearch,SultanChandandsons,NewDelhi.
3. J.K.Sharma,OperationsResearchand Application,Mc.MillanandCompany,NewDelhi.
4. GassS.I:LinearProgramming.McGrawHill.
5. HadlyG:Linearprogramming.Addison-Wesley.
6. TahaH.M:OperationsResearch:AnIntroduction:MacMillan.

Practical/LabtobeperformedonacomputerusingOR/Statisticalpackages

1. TosolveLinearProgrammingProblemusingGraphicalMethodwith
   - (i) Unboundedsolution
   - (ii) Infeasiblesolution
   - (iii) Alternativeormultiplesolutions.
2. SolutionofLPPwithsimplexmethod.
3. Problemsolvingusing Charne'sM-method.
4. Problemsolvingusing TwoPhasemethod.
5. IllustrationoffollowingspecialcasesinLPPUsingSimplexmethod
   - (i) Unrestrictedvariables
   - (ii) Unboundedsolution
   - (iii) Infeasiblesolution
   - (iv) Alternativeormultiplesolutions.
6. ProblemsbasedonPrincipleofDuality.
7. ProblemsbasedonDualsimplexmethod.
8. ProblemsbasedonPostOptimalAnalysis.

Objective:Toenrichtheknowledgeofstudentswithadvancedtechniquesoflinearprogrammin gproblem alongwithreal lifeapplications.

LearningOutcomes:

Afterlearningthiscourse,thestudentwillbeable
1. Tosolvetheproblemsinlogistics
2. Tofindasolutionfortheproblemshavingspaceconstraints
3. Tominimizethetotalelapsedtimein anindustrybyefficientallocationofjobstothesuitable persons.
4. Tofindasolutionforanadequateusageofhumanresources
5. To findthemostplausiblesolutionsinindustriesandagriculturewhenarandomenvironme ntexists.

UNIT-I

TransportationProblem-
Introduction,MathematicalformulationofTransportationproblem.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 transportationproblem.Maximization TP.TransshipmentProblem.

UNIT-II

AssignmentProblem-
Introduction,MathematicalformulationofAssignmentproblem,Reductiontheorem(statementonly), HungarianMethodforsolvingAssignmentproblem,Unbalanced Assignment problem.The Traveling salesman problem, Formulation of Travelingsalesmanproblemas anAssignmentproblemandSolutionprocedure.

UNIT-III

Sequencing problem: Introduction and assumptions of sequencing problem, Sequencing of n jobsand one machine problem.Johnson's algorithm for n jobs and two machines problem-problemswith 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, problemswithn-jobsonm-machines.Graphical methodfortwojobsonm–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)andPERT.

UNIT–V

GameTheory:Two-personzero-sumgames.PureandMixedstrategies.Maxmin and MinimaxPrinciples-Saddlepointanditsexistence.GameswithoutSaddlepoint-
Mixedstrategies.Solutionof2x2rectangulargames.Graphicalmethodofsolving2xnandm x 2 games.Dominance Property.Matrix oddment method for n x n games.OnlyformulationofLinearProgrammingProblemform x ngames

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ReferenceBooks:

1. S.D.Sharma,OperationsResearch,KedarNathRamNath&Co,Meerut.
2. KantiSwarup,P.K.Gupta,Manmohn,OperationsResearch,SultanChandandsons,NewDelhi.
3. J.K.Sharma,OperationsResearchand Application,Mc.MillanandCompany,NewDelhi.
4. Gass:LinearProgramming.McGrawHill.
5. Hadly:Linrarprogramming.Addison-Wesley.
6. Taha:OperationsResearch:AnIntroduction:MacMillan.
7. Dr.NVSRaju;OperationsResearch,SMSeducation,

Practical/LabtobeperformedonacomputerusingOR/Statisticalpackages

1. IBFSoftransportationproblembyusingNorth-Westcorner rule,MatrixminimummethodandVAM
2. OptimumsolutiontobalancedandunbalancedtransportationproblemsbyMODImethod(both maximizationandminimizationcases)
3. SolutionofAssignmentproblemusingHungarianmethod(bothmaximizationandmini mizationcases),
4. Solutionofsequencing problem—processing ofn jobsthroughtwomachines
5. Solutionofsequencing problem-processing ofn jobsthroughthree machines
6. ToperformProjectschedulingofagivenproject(Deterministiccase-CPM).
7. ToperformProjectschedulingofagivenproject(Probabilisticcase-PERT).
8. Graphicalmethod ofsolvingformx2and2xngames.
9. Solutionofmxngamesbydominancerule.
10. Solutionofnxngamesbyusingmatrixoddmentmethod.
11. Linearprogrammingmethod forsolvingmxngames.

Course Objectives: To understand the concept of quality, process control and product controlusing control chart techniques and sampling inspection plan. To have an idea about qualitymanagement,qualitycircles,quality movementandstandardizationsforquality.

LearningOutcomes:
Afterlearningthiscourse,thestudentwillbeable
1. Todefine'quality' inascientificway
2. Todifferentiatebetweenprocesscontroland productcontrol
3. Tospeakaboutqualityawareness inindustry
4. To paveapathtoanindustrytomeetthestandards
5. Toeffectivelyimplementvariousplanstocontrolthequalitystandardsatvariousstagesofanindustry.

UnitI

Meaningofquality,conceptoftotalqualitymanagement(TQM)andsix-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 concentrationdiagram(vi)ScatterDiagram(vii)Controlchart.(Onlyintroductionof7toolsisexpected).

UnitII

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 assignablecauses of variation, justification for the use of 3-sigma limits for normal distribution, Criteria fordetectinglackofcontrolsituations:

(i) Atleastonepointoutsidethecontrollimits

(ii) Arunofsevenormorepointsaboveorbelowcentralline.

Unit III

Control chartsfor Variables: Introductionand Constructionof $\bar{X}$nd Rchart and Standard Deviation Chart when standards are specified and unspecified, corrective action if the process isoutofstatisticalcontrol.

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

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.

TextBooks:

1. **Montgomery, D.C. (2008)**: Statistical Quality Control, 6th Edn., 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).

Course7B:
ComputationalTechniquesandRProgramming
(Skill Enhancement Course (Elective), 05
CreditsMax.Marks:Theory:100 +
Practicals:50

CourseObjectives: To learnthestatisticalanalysiswiththehelp ofthestatisticalsoftwareR

LearningOutcomes:

Afterlearningthiscoursethestudentwillbeable

1. Understandthebasicfunctioning ofacomputer
2. AcquireskillsinhandlingbusinessandorganizationaldatausingExcel
3. PerformsimpleanalyticsusingExcel
4. UnderstandthepowerofRprogramminglanguage
5. Handle variousstatisticalissuesusingR language

UnitI

Computerbasics:Basic applications of computer,components of computersystem,CentralProcessing Unit (CPU), input and output units, computer memory and mass storage devices.Programming languages and their applications.Concept of files and folders.Software and typesofsoftware.OperatingSystemlikeWindowsandLinux.

UnitII

Data processing using spreadsheets – Data entry and editing features in Excel, copy, paste, pastespecial options, sort and filter options, auto sum, steps of finding average and standard deviationof data using statistical functions.Matrix operations like transpose, multiply and inverse usingExcel functions.Simple graphs like bar chart, line chart and pie chart in Excel.Exporting Exceloutputtoword processerslikeMS-Wordand slidepresentationslike PowerPoint.

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-testand one-wayAnalysisofVariance usingData AnalysisPak.P-value anditsinterpretation.

UnitIV

Programming with R: Introduction to R, Data types in R (numeric, logical, character, complexetc.), R objects: vector, matrix, array, list, data frame, factor, and time series. Arithmetic, logicaland relational operators, explicit and implicit looping, functions and functional programming inR, Lexical scoping rules in R, benefits of Lexical scoping, other scoping rules, debugging facilityin R.Fewimportant mathematical,statisticalandgraphicalfunctionsinR.

UNIT-V

DescriptiveStatisticswithRsoftware:CalculationswithRsoftwaresuchasdescriptivestatistics, frequency distribution, Graphics and plots, statistical functions of central tendency,variation,skewnessandkurtosisandillustrationwithexamples.

SuggestedBooks

1. Chambers,J. (2008).SoftwareforDataAnalysis:ProgrammingwithR,Springer.
2. Crawley, M.J.(2017).TheRBook,JohnWiley&Sons.
3. Eckhouse,R.H.andMorris,L.R.(1975).MinicomputerSystemsOrganization,Programminga ndApplications,Prentice-Hall.
4. Matloff, N. (2011).TheArtofRProgramming,NoStarchPress,Inc.
5. PeterN.(1986).InsidetheIBMPC,Prentice-HallPress.
6. Dr.MarkGardener(2012):BeginningRThestatisticalProgrammingLanguages,JohnWiley& Sons.
7. K.V.S.Sarma(2010),StatisticsMadeSimple–DoityourselfonPC,2ndEdition,Prentice HallIndia
8. SudhaG.Purohit,SharadD.Gore,andShailajaR.Deshmukh(2008),StatisticsUsingR,Narosa PublishingHouse,India.
9. Crawley, M.J. (2006).Statistics–AnintroductionusingR. JohnWileyLondon.
10. Purohit,S.G.,Deshmukh,S.R.andGore,S.D.,(2015):StatisticsusingR,AlphaScienceInternati onal.
11. Verzani,J.,(2018):UsingR forintroductorystatistics.CRCpress.
12. Schumacker,R.E.,(2014):LearningstatisticsusingR.SagePublications.
13. MichaleJ.Crawley(2009),THERBOOK,JohnWiley&Sons.

Practical/LabtobeperformedonacomputerusingRSoftware

1. ConstructionofBarChartandPieChartusingExcel
2. Fittingofstraight-lineusing Excel
3. CalculatingMatrixInverseusingExcel
4. Oneway ANOVAusing Excel
5. DatavisualizationusingR -frequencypolygon, Ogives, Histogram.
6. DatavisualizationusingR-simpleandmultiplebardiagram,piechart.
7. ComputationofDescriptiveStatisticsusingR- CentralTendencies,Dispersions,Moments,Skewness andKurtosis.
8. ComputationofKarlPearson'sCoefficientofCorrelationand RankCorrelationusingR.
9. ConstructionofControlChartsforvariables($\bar{X}$Randσ)chartsusingR.
10. ConstructionofControl Chartsforattributes(p,npchartswithfixedandvaryingsamplesizes)usingR.
11. ConstructionofControlChartsusingR -CandUcharts.

Course6C:**ECONOMETRICS**
(SkillEnhancementCourse(Elective),
Max.Marks:Theory:100+ Practicals:50
05 Credits

LearningOutcomes:

The course on econometrics will primarily focus on the use of statisticalmodeling and therelevant analyses to economic data problems. After learning this course the student will be ableunderstand

1. variousimportanteconometricmodelsandrelevantmodelbuildingconceptsineconometrics
2. generallinearmodelsandestimationofinherentmodelparameters
3. multicollinearity,itsdetectionandconsequencesandrelatedinferentialaspects
4. someadvancedconceptsofgeneralisedleastsquaresestimation,autocorrelation,itsconsequences,detectionandstrategyforreducingautocorrelation,
5. heteroscedasticityanditsinherent conceptsincludingitsconsequences,
6. some inferentialaspectsonheteroscedasticity,
7. practicalaspectsand realdataillustrationoftherelatedproblems.

UNIT-I

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

UNIT-II

Models and Estimations:Simple regression models- twovariablelinearregression model,assumptions and estimation of parameters.Gauss Markoff theorem, OLS estimations, partialand multiple correlations coefficients.The general linear model assumptions, estimation andpropertiesofestimators,BLUEs.

UNIT- III

Heteroscedasticdisturbances : Tests of significance of estimators, R square and ANOVA.Concepts and consequences of heteroscedasticity.Tests and solutions of heteroscedasticity.Specificationerror,Errorsofmeasurement.

UNIT-IV

Multicollinearity:Theconceptofmulticollinearityanditsconsequencesoneconometricmodels, detection of multicollinearity. Measure of Multicollinearity – Variance Inflation Factor(VIF)andtolerance,formulaandinterpretation.Methodsofreducingtheinfluenceofmulticollinearity.

UNIT-V

Autocorrelation: Disturbanceterm(u)ineconometricmodelsanditsassumptions,autocorrelateddisturbancesandtheirconsequenceson themodel parameters,Detectingthepresence of autocorrelation – hypothesis tests for autocorrelation - Durbin Watson test and itsinterpretation.

References:

1. Gujarati,D.andSangeetha,S.(2007).BasicEconometrics,4thEdition,McGrawHillCompanies.
2. Johnston,J.(1972).EconometricMethods,2ndEdition,McGrawHillInternational.
3. Koutsoyiannis,A.(2004).TheoryofEconometrics,2ndEdition,PalgraveMacmillanLimited.
4. Maddala,G.S.andLahiri,K.(2009):IntroductiontoEconometrics,4thEdition,JohnWiley&Sons.

Practical/Labtobeperformed onacomputer usingStatisticalpackages

1. ProblemsbasedonestimationofGenerallinearmodel.
2. TestingofparametersofGenerallinearmodel.
3. ForecastingofGenerallinearmodel.
4. Problemsconcerningspecificationerrors.
5. ProblemsrelatedtoconsequencesofMulticollinearity.
6. DiagnosticsofMulticollinearity.
7. ProblemsrelatedtoconsequencesofAutocorrelation(AR(I)).
8. DiagnosticsofAutocorrelation.
9. EstimationofproblemsofGenerallinearmodelunderAutocorrelation.
10. ProblemsrelatedtoconsequencesHeteroscedasticity.
11. DiagnosticsofHeteroscedasticity.
12. EstimationofproblemsofGenerallinearmodelunder Heteroscedasticdistanceterms.

Course7C: **REGRESSION ANALYSIS**
(SkillEnhancementCourse(Elective),05Cr editsMax.Marks:Theory:100+ Practicals:50

LearningOutcomes:

Afterlearningthiscoursethestudentwillbeable

1. Toknowaboutregressiontechniques,whicharepowerfultoolsinstatistics,
2. TogetanideaofLinearandMultipleLinearregression,
3. Tolearnaboutregressiondiagnostics,residualplots forvisualization
4. To performstatisticaltestsofhypothesesonregressioncoefficients.
5. Tostudythestructuralstabilityofaregressionmodel.
6. Tolearntheregressionwithqualitativeindependentanddependentvariablesbydummyvariable technique.
7. Tolearntheselectionofthebestregressionmodel.

UnitI

Simple Linear Regression: Simple Linear Regression Model. Least-Squares Estimation of theParameters - Estimation of $\beta_0$and β_1, Properties of the Least-Squares Estimators and the FittedRegression Model.Hypothesis Testingon the Slope andIntercept-Use of t Tests, TestingSignificanceofRegressionandAnalysisofVariance

UnitII

MultipleLinearRegression:Multiplelinearregression:MultipleLinearRegressionModel.Estimation ofmodelparameters:Least-SquaresEstimationoftheRegressionCoefficients,PropertiesoftheLeast-SquaresEstimators.Conceptofresidual,Residualplots.TestforSignificanceofIndividualRegressionCoefficients,andsubsetsofcoefficients.Conceptofcoefficientofdetermination.

Unit III

RegressionswithQualitativeIndependentVariables:Useofdummyvariablestohandlecategorical independent variables in regression. Estimation of model parameters with dummyvariables - Testing the structural stability of regression models, comparing the slopes of tworegressionmodels.Multiplelinearregressionwithinteractioneffects.

Unit-IV

Regressions with Qualitative Dependent Variables:Binary logistic regression with severalindependentvariables,estimationof coefficients,evaluatingtheOddsRatio(OR)anditsinterpretation.The concept of Piecewise linear regression, The Logit,Probit and Tobit modelsandtheirapplications.

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.