Bachelor of Science (Basic/Hons.)

With Statistics as one of the majors with practicals with other subject asanother major in 3rd year

(III and IV semesters)

Program Structures for the Under-Graduate Programs in Universities and Colleges

Bachelor of Science (Basic/Hons.) /Bachelor of Arts (Basic/Hons.) With Statistics as one of the majors with practicals with other subject as another major

Sem.	Discipline Core (DSC)(Credits) (L+T+P)	Discipline Elective(DSE) / Open Elective (OE) (Credits) (L+T+P)	Ability Enhancement Compulsory Courses (AECC), Languages (Credits)(L+T+P)		Skill Enhancement Courses (SEC)		Total Credits
					Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)	
I	**Descriptive Statistics** (4+2) Discipline B1(4+2)	OE-1 (3)	L1-1 (3), L2-1 (3)(3+1+0 each)		SEC-1: Digital Fluency (2) (1+0+2)		25
II	**Probability and Distributions** (4+2)Discipline B2(4+2)	OE-2 (3)	L1-2(3), L2-2 (3) (3+1+0 each)	Environmental Studies (2)		Health & Wellness/ Social & Emotional Learning (2) (1+0+2)	25
Exit option with Certificate (48 credits)							
III	**Calculus and Probability Distributions** (4+2) Discipline B3(4+2)	OE-3 (3)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2: Artificial Intelligence (2)(1+0+2)		23
IV	**Statistical Inference-I** (4+2) Discipline B4(4+2)	OE-4 (3)	L1-4 (3), L2-4(3) (3+1+0 each)	Constitution of India (2)		Sports/NCC/NSS etc. (2) (1+0+2)	25
Exit option with Diploma (96 credits)							
V	**Matrix Algebra and Regression Analysis** (3+2) **Analysis of variance and design of experiments** (3+2) Discipline B5(3+2)	DS-B Elective 1 (3)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Awareness (2) (1+0+2)?	20
VI	**Statistical Inference-II** (3+2) Discipline B6(3+2) Discipline B7(3+2)	DS-A Elective 1 (3)			SEC-4: Professional/ Societal Communication (2)		20
Exit option with Bachelor of Arts, B.A. / Bachelor of Science, B. Sc. Basic Degree (136 credits)							
Choose any one Discipline as Major							

VII	**Sample Surveys and Statistics for National Development** (3+2) **Real Analysis** (3+2) **Probability Theory** (4)	DS-A/B Elective 2(3) Res. Methodology(3)					20
VIII	**Linear Algebra** (4) **Linear models and Design of Experiments** (4)	DS-A/B Elective 3(3) DS-A/B Elective 4(3) Research Project (6)*					20
Award of Bachelor of Arts Honours, B.A. (Hons.)/ Bachelor of Science Honours, B.Sc. (Hons) degree in a discipline etc. (176 credits)							
IX	**Multivariate Analysis** (3+2) **Decision Theory and Bayesian Inference** (3+2) **Distribution Theory** (4)	DS-A/B Elective 2(3) Res. Methodology(3)					20
X	**Stochastic Processes** (4) **Time Series Analysis** (4)	DS-A/B Elective 3(3) DS-A/B Elective 4(3) Research Project (6)*					20
Award of Master of Science Degree in Statistics							

Summary of Discipline Specific Courses (DSC)			
Semester	**Course Code**	**Title of the Paper**	**Credits**
I	DSC A1	Descriptive Statistics	4
		Practicals based on DSC A1	**2**
II	DSC A2	Probability and Distributions	4
		Practicals based on DSC A2	2
III	DSC A3	Calculus and Probability Distributions	4
		Practicals based on DSC A3	2
IV	DSC A4	Statistical Inference-I	4
		Practicals based on DSC A4	2
V	DSC A5	Matrix Algebra and Regression Analysis	3
		Practicals based on DSC A5	2
	DSC A6	Analysis of variance and design of experiments	3
		Practicals based on DSC A6	2
VI	DSC A7	Statistical Inference-II	3
		Practicals based on DSC A7	2
VII	DSC A8	Sample Surveys and Statistics for National Development	3
		Practicals based on DSC A8	2
	DSC A9	Real Analysis	3
		Practicals based on DSC A9	2
	DSC A10	Probability Theory	4
VIII	DSC A11	Linear Algebra	4
	DSC A12	Linear models and Design of Experiments	4
IX	DSC A13	Multivariate Analysis	3
		Practicals based on DSC A13	2
	DSC A14	Distribution Theory	3
		Practicals based on DSC A14	2
	DSC A15	Decision Theory and Bayesian Inference	4
X	DSC A16	Stochastic Processes	4
	DSC A17	Time Series Analysis	4

Syllabus for III and IV Semester B.Sc. with Statistics as Major

Assessment for Discipline Specific Core(DSC)
Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	**40**	**60**
Practical	**25**	**25(20+5(Practical record))**

III Semester B.Sc.,

Course Title: **Calculus and Probability Distributions**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Summative Assessment Marks: 60	

Number of Theory Credits	Number of lecture hours/semester	Number of practical Credits	Number of practical hours/semester
4	**56**	**2**	**52**

Course Objectives

To enable the students to

1. Know the concept of continuity, differentiability, integration of one and more variables.
2. Define and describe properties of Joint, Marginal and conditional distributions of variables and some key concepts of probability theory.
3. Understand different discrete, continuous and sampling distributions, properties and their applications.
4. Generate random variables from various distributions using R-code.

Course Outcomes

After completion of this course the students will be able to

1. Judge continuity of a function, find integrations and solve problems of differentiability.
2. Solve problems of various analytical environments using different distributions and their properties.
3. Find sampling distributions of functions of random variables and explore their applications.

Theory Paper 3 ' Calculus and Probability Distributions'

Content of Theory Paper 3	56 Hrs
UNIT 1: Calculus of one and more variables	**15 Hrs**
Review of calculus of one variable: continuity, differentiability, mean value theorem and Taylor series expansion. Functions of several variables: Continuity, directional derivatives, differentials of functions of several variables, the gradient vector. The mean value theorem, a sufficient condition for the existence of the differential, partial derivatives of higher order and Taylor's formula. Applications of partial differentiation, Jacobian. Riemann integrals, integration by parts, mean value theorem. Multiple integrals and evaluation of multiple integrals by repeated integration, Mean-value theorem for multiple integrals. Sequences and Series of real numbers. convergence of sequences and series, tests for convergence of series. (Only results and applications)	
UNIT 2: Distribution of Random Variables (Two-dimensional)	**12 Hrs**
Two dimensional random variables: Joint distribution, Marginal distribution and Conditional distributions of random variables, conditional expectation, covariance, correlation and moments. Distribution of functions of random variables using m.g.f. and distribution function. Transformationof variable technique (one and two variables). Chebyshev's inequality- proof and its use in approximating probabilities; Convergence in law and convergence in probability. Statements of Weak Lawof Large Numbers; and Central Limit theorems – De-Moivre. (Some simple examples)	
UNIT 3: Probability Distributions-II	**16 Hrs**

Discrete distributions: Rectangular, Geometric, Negative Binomial, Hypergeometric, Multinomial- definition through probability mass function, mean, variance, moments, p.g.f., m.g.f., other properties and applications. Continuous distributions: Uniform, Gamma, Normal, Exponential, Beta (type 1 and type 2), Cauchy, Weibull– definition through probability density function, mean, variance, moments, m.g.f., other properties and applications. Bivariate normal distribution- definition through probability density function, marginal and conditional distribution.	
UNIT 4: Sampling Distributions and Simulation	**13 Hrs**
Definitions of random sample, parameter and statistic, sampling distribution of sample mean, standard error of sample mean, sampling distribution of sample variance, standard error of sample variance. Definition and derivation of Student t, Chi-square and F-Distribution-their properties, mean and variance. Limiting form of t distribution. Exact sampling distributions: Distribution of sample mean $\bar{x}$ and sample variance S^2 under normality assumption. when sampling from normal population. Assuming the independence of sample mean $\bar{x}$ and sample variance S^2 when sampling from normal population derive the distribution of $\frac{\bar{x}}{\sqrt{\frac{S^2}{n}}}$. Distribution of 1/F. Relationshipbetween t, F and χ^2 distributions. Introduction to simulation. Generation of random observations from Uniform, Exponential, Normal, Binomial, Poisson distributions using R-codes.	

Text Books:

1. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12th Edition.
2. Shanthi Narayana (2000), Integral Calculus, S. Chand & Co. Ltd.

References

1. Andre I Khuri (2003). Advanced Calculus with Applications in Statistics, Second Edition, John Wiley & Sons.
2. Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer
3. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
5. Jay Kerns, G. (2010). Introduction to Probability and Statistics using R. 1st Edition,

Springer.
6. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
7. Ross, S. M. (2014). Introduction to Probability Models. 11th Edition, Elsevier science.
8. Ross, S. M. (2012). Simulation. Academic Press.
9. Shanti Narayana (2000). Differential Calculus, S. Chand & Co. Ltd.
10. Verzani, J. (2002). Simple R - Using R for Introductory Statistics.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

Formative Assessment: Total 40 marks	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	40

Summative Assessment : Total Marks :60			
	Questions to be answered	Marks	Total marks
Part A	Three questions out of Five questions	3x2	06
Part B	Four questions out of Eight questions	4x6	24
Part C	Three questions out of Five questions	3x10	30
Total			60

Contents of Practical 3

Note: The first practical assignment is on R-programming. Practical assignments 2 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

1. Demonstration of R functions for calculus, distribution of random variables, probability distributions, sampling distribution simulation.
2. Numerical differentiation and integration.
3. Bivariate Probability Distributions - Marginal and Conditional distributions,
4. Bivariate Probability Distributions - Conditional Mean, Conditional Variance, Correlation.
5. Applications of Chebyshev's inequality (For standard distributions such as Normal, Exponential, Gamma).
6. Applications of discrete probability distributions - Negative – Binomial, Geometric, Hyper geometric and discrete uniform, multinomial distributions.
7. Applications of continuous probability distributions - Exponential, Gamma, Cauchy, Weibull distributions.
8. Fitting of discrete and continuous distributions.
9. Generating random sample from discrete distributions.
10. Generating random sample from continuous distributions.

Formative Assessment: Total 25 marks	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	25

Summative Assessment : Total Marks 25		
Total Number of Five marks questions	Questions to be answered	Total Marks
8	4	4x5= 20
	Class Record	05
	Total Marks	25

IV Semester B.Sc.

Course Title: **Statistical Inference-I**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Summative Assessment Marks: 60	

Number of Theory Credits	**Number of lecture hours/semester**	**Number of practical Credits**	**Number of practical hours/semester**
4	**56**	**2**	**52**

Course Objectives

To enable the students to understand the concepts of

1. Families of distributions, order statistics and their distributions.
2. Estimation, criteria for estimators, methods of estimation, confidence interval.
3. Testing of Hypotheses and its theoretical aspects, large and small sample tests.

Course Outcomes

After completion of the course, the students will be able to

1. Carryout statistical analysis by identifying families of distributions and the use of order statistics.
2. To find estimators using different methods of estimation and compare estimators.
3. To carryout statistical inference using different tests of hypotheses under different scenarios.
4. Generate random variables and use these generated random variable for illustration of concepts studied in this course.

Theory Paper 4 'Statistical Inference-I'

Content of Theory Paper 4	56 Hrs
UNIT 1: Point Estimation-I	**16 Hrs**
Families of distributions- location and scale families. Single parameter exponential family. Concept of order statistics, Distribution of maximum and minimum order statistics (with proof) and r^{th} order statistic (without proof). Concepts of estimator and estimate. Criteria for estimators: Unbiasedness, Consistency. Invariance property of consistent estimators. Efficiency and relative efficiency. Mean squared error as a criterion for comparing estimators. Sufficient statistics. Statement of Neyman-Factorization theorem.	
UNIT 2: Point Estimation-II	**12 Hrs**
Fisher information function. Statement of Cramer–Rao inequality and its applications. Minimum Variance Unbiased Estimator and Minimum Variance Bound Estimator. Maximum likelihood and method of moment estimation; Properties of MLE and moment estimators and examples. Method of Scoring	
UNIT 4: Interval Estimation	**10 Hrs**
Confidence interval, confidence coefficient, shortest confidence interval. Methods of constructing confidence intervals using pivotal quantities. Construction of confidence intervals for mean, difference of two means, variance and ratio of variances, proportions, difference of two proportions and correlation coefficient.	
UNIT 3: Testing of Hypotheses	**18 Hrs**
Statistical hypotheses - null and alternative, Simple and composite hypotheses. Type-I and Type-II errors, test functions. Randomized and non-randomized tests. Size, level of significance, Power function, power of tests. Critical region, p- value and its interpretation. Most Powerful (MP) and UMP test. Statement of Neyman-Pearson Lemma and its applications. Likelihood ratio tests. Large and small samples tests of significance. Tests for single mean, equality of two means, single variance and equality of two variances for normal populations. Tests for proportions. .	

Text Books:

1. **1.** Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, SultanChand and Co. 12^{th} Edition.
2. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theoryand Mathematical Statistics, New York, John Wiley.
3.

References

4. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R. Wiley.

5. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
6. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
7. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.
8. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa Publishing House.
9. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal Book Stall.
10. Ross, S.M. (2014), Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

Formative Assessment: Total 40 marks	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	40

Summative Assessment : Total Marks :60			
	Questions to be answered	Marks	Total marks
Part A	Three questions out of Five questions	3x2	06
Part B	Four questions out of Eight questions	4x6	24
Part C	Three questions out of Five questions	3x10	30
Total			60

Contents of Practical 4

Note: The first practical assignment is on R-programming and R packages. Practical assignments 2 to 10 have to be first solved manually (using scientific calculators) and executed using R-programming.

1. Demonstration of R-functions for estimation and testing of hypotheses.
2. Point estimation of parameters and obtaining estimate of standard errors and mean square error.
3. Computing maximum likelihood estimates.
4. Computing moment estimates.
5. Interval estimation: Construction of confidence interval (large and small samples)
6. uation of Probabilities of Type – I and Type – II errors and power of tests.
7. Small sample tests: Tests for mean, equality of means under normality when variance is (i) known (ii) unknown, P-values.
8. Small sample tests: single proportion and equality of two proportions, variance and equality of two variances under normality. P-values for the above tests.
9. Large sample tests: Tests for mean, equality of means when variance is (i) known (ii) unknown, under normality, variance and equality of two variances under normality. P-values for the above tests.
10. MP and UMP tests for parameters of binomial, Poisson distributions, normal and Exponential (scale parameter only) distributions and power curve.

Formative Assessment: Total 25 marks	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test 1	10
Internal Test 2	10
Attendance	5
Total	25

Summative Assessment : Total Marks 25		
Total Number of Five marks questions	Questions to be answered	Total Marks
8	4	4x5= 20
	Class Record	05
	Total Marks	25

OPEN ELECTIVE PAPERS:

OE-3: Applied Statistics

OE-4: Biostatistics

OE-3.Applied Statistics

CourseTitle: Applied Statistics	Course Credits:3
Total Contact Hours:42	Duration of ESA:2 hours
Formative Assessment Marks:40	Summative Assessment Marks:60

CourseObjectives

- To enable the students to use statistical tools in finance, industries, population studies and health sciences.
- To acquire knowledge about sampling methods for surveys.

CourseOutcomes (COs)

Upon successful completion of this course, the student will be able to:

CO1.Understand the Price and Quantity Index numbers and their different measures,understand the applicability of cost of living Index number.
CO2.Know the components and Need for Time series,
understand the different methods of studying trend and Seasonal
Index.
CO3.Studytheconceptofvitalstatistics,sourcesofdata,differentmeasuresofFertilityandMortality,
Understand the Growth rates-GRR and NRR and their interpretations.
CO4.Know the concept of Population, Sample, Samplingunit, samplingdesign, sampling frame, sampling scheme, need for sampling , apply the different sampling methods for designing and selecting a sample from a population, explain sampling and non-sampling errors.
CO5.Describe the philosophy of statistical quality control tools as well as their usefulness in industry and hence develop quality control tools in a given situation.

Pedagogy

- The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
- Students are encouraged to use resources available on open sources.

Course Contents

Unit1:EconomicStatistics 12Hour

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number.Usesand limitations of index numbers. Consume rprice index number: construction of consumer price index

numbers. Applications of consumer price index numbers
Time Series Analysis: Components of time series, Decomposition of time series-Additiveandmultiplicativemodelwiththeirmeritsanddemerits,Illustrationsoftimeseries. Measurementoftrendbymethodoffree-handcurve,methodofsemi-averagesandmethodofleastsquares(linear).Measurement of seasonal variations by method of ratio to trend.

Unit2:VitalStatistics 12Hours

Sources of demographic data, errors in data. Measurement of mortality: crude death rate, specific death rates, and standardized death rates, infant mortality rate, maternal mortality
rate,neonatalmortalityrates,meritsanddemeritsandcomparisonsofvariousmortalityrates. Measurement of Fertility and Reproduction: Fecundity, fertility, measurement of fertility, crude birth rate,
generalfertilityrate,agespecificfertilityrateandtotalfertilityrates,meritsanddemeritsofeachmeasureo
ffertility,comparativestudyofthesemeasuresoffertility,Growthrates:Grossreproductionrate and Net reproduction rates.

Unit3:SamplingMethods 10Hours

PopulationandSample.Needforsampling,CompleteEnumerationversusSampleSurveys, Merits and Demerits, Non-Probability and Probability Sampling, Need and illustrations.Useofrandomnumbers,principalstepsinsamplesurvey.Requisitesofagoodquestionnaire.Pilot

surveys, Sampling and non – sampling errors, Description of simple random sampling withandwithoutreplacementprocedures,MeritsanddemeritsofSimplerandomsampling. Needforstratification,stratifyingfactors,Meritsanddemeritsofstratifiedrandomsampling. Systematicrandom sampling procedure of obtaining sample, Merits and demerits of systematic random sampling.

Unit4:StatisticalQualityControl 08Hours

ConceptofqualityanditsmanagementCausesofvariationsinquality:chanceandassignable. General theory of control charts, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts.

References

1. J.Medhi(1992)StatisticalMethods.NewAgeInternational(P)Ltd.NewDelhi.
2. M.N.Das(1993)StatisticalMethodsandConcepts.WileyEasternLtd.
3. IrwinMiller,
JohnEFreundandRichardAJohnson(1992)ProbabilityandStatisticsforEngineers.PrenticeHal
lofIndia NewDelhi.
4. D.C.Montgomery(1996)IntroductiontoStatisticalQualityControl.
5. Cochran,WG.(1984)SamplingTechniques,WileyEastern,NewDelhi.
6. MukhopadhayaP(1998)TheoryandMethodsofSurveySampling.PrenticeHallofIndia.
7. MukhopadhyayP.(2011): AppliedStatistics,2nded.Revisedreprint,BooksandAllied
8. KendallM.G.(1976):Time Series, CharlesGriffin.
9. ChatfieldC.(1980):TheAnalysisofTimeSeries–AnIntroduction,Chapman&Hall.

OE-4.Biostatistics

CourseTitle:Biostatistics	CourseCredits:3
TotalContactHours:42	Duration of ESA:2 hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Course Objectives

To understand the data types, types of variables and scales of measurement.

1. To understand different descriptive statistics in data analysis. Present data summary in tabular form and graphs.
2. To understand importance of random sampling and sampling technique.
3. To understand the concept of uncertainty in biological sciences and basics of probability and probability distributions.
4. To understand the concept of testing of hypothesis and errors in decision making
5. To know about bivariate and multivariate data, Measures of relationship: correlation and regression.

Course Learning Outcomes

After studying the course, the student will be able to apply statistical tools and techniques in data analysis of biological sciences.

Pedagogy

- Thecourseistaughtusingtraditionalchalkandtalkmethodusingproblemsolvingthr oughexamplesandexercises.
- Students are encouraged to use resources available on open sources.

Course Contents

Unit1: Introduction to Bio-Statistics 10 hours

Statistics and Health Science, Role of Biostatistics in Life Sciences.
DefinitionandscopeofStatistics.ScalesofMeasurement:nominal,ordinal,intervalandratio.Collection,cla ssificationandtabulationofdata,constructionoffrequencytableforgroupedandungroupeddata,graphicalre presentationofdatabyhistogram,polygon,ogivecurvesandPiediagram.

Unit2:DescriptiveStatistics 12hours

Measures of Central Tendency: Arithmetic mean, Median and Mode-definition, properties, merits and limitations.
Measures of Dispersion:Range,Standard deviation and Coefficient ofVariation. Correlation and Regression Analysis: Bivariate Data ,Scater Diagram, definition of correlation, types of correlation, Karl-Pearson's coefficient of correlation and its properties, Spearman's Rank Correlation coefficient. Regression-Simple linear regression,f itting of regression equations by method of Least Squares, regression coefficients and their properties and interpretation.

Unit3: Probability and Probability Distributions 10Hours

Probability: Random experiment, sample space, events-mutually exclusive and exhaustiveevents.Classical,statisticalandaxiomaticdefinitionsofprobability,additionandmultiplication theorems,Bayes'theorem(onlystatements) and its application. Sensitivity, Specificity, positive predictive value, negative predictive value,odds ratio.
Discrete and continuous random variables, probability mass and density functions, distribution functions, expectation of a random variable. Standard univariate distributions:Bernoulli,Binomial,Poisson and Normal distributions(Elementary properties and applications only).

Unit4: SamplingDistributionsandStatisticalInference 10hours
Concepts of random sample and statistic, distribution of sample mean from a normal population,Chi-square,tandFdistributions(Noderivations)andtheirapplications.Estimationofpopulationmean,populatio nstandarddeviationandpopulationproportionfromthesamplecounterparts.Statisticalhypothesis:nulland alternativehypothesis,simpleandcompositehypothesis.TypeIandTypeIIerrors,size,levelofsignificance, powertest,criticalregion, P-value and its interpretation.Test fors ingle mean,equality of two means, s ingle variance, equality of two variances for normal Populations, Test for proportions. ANOVA and Nonparametric Tests.

References

1. Dutta,N.K.(2004),Fundamentals of Biostatistics, Kanishka Publishers.

2. GurumaniN.(2005),AnIntroductionto Biostatistics,MJPPublishers.
3. Daniel,W.W.(2007),Biostatistics-AFoundationforAnalysisintheHealthSciences,Wiley
4. Rao,K.V.(2007),Biostatistics-
AManualofStatisticalMethodsforuseinHealthNutritionandAnthropology
5. Pagano,M.andGauvreau,K.(2007),PrinciplesofBiostatistics.
6. RosnerBernard(2010), FundamentalsofBiostatistics,6thEdition,Duxbury.

Detailed Syllabus for Semesters

I Semester & II Semester B.Sc., Minor Statistics

Course Content of Semester–I ; STATISTICS -I

CourseTitle: **Statistics I**	Course Credits: 3
Total Contact Hours: 42	Duration of ESA:2hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Course Title: Statistics I

Theory Content of Statistics I	**42 hrs**
Unit–1:Introductionto Statistics	**13hrs**
Statistics:Definitionandscope.Data:quantitativeandqualitative,crosssectionalandtime-series, discreteandcontinuous.Scalesofmeasurement:nominal,ordinal,intervalandratio.Presentationofdata:tabular and graphical. Frequency distributions, cumulativefrequencydistributionsandtheirgraphicalrepresentations.Stemandleafdisplays.Conceptsofpopulationandsample.Methodsofsampling-SRS,Stratified,SystematicandClustersamplingmethods:definitionsonly.	
Unit–2:UnivariateDataAnalysis	**17hrs**
Concept of measures of central tendency and measures ofdispersion.Mean,weightedmean,trimmedmean,Median,Mode,Geometricandharmonicmeans,properties,meritsandlimitations,relationbetweenthesemeasures.Range,Quartiledeviation,Meandeviation,Standarddeviation andtheirrelativemeasures.Gini'sCoefficient,LorenzCurve.Moments,Skewness and Kurtosis. Portion Values and measures based on them. Box Plot. Outliers, normal datasets.	
Unit–3:BivariateDataAnalysis	**12hrs**
BivariateData,Scatterplot,Correlation,KarlPearson'scorrelationcoefficient,Rankcorrelation:Spearman'sandKendall'smeasures.Functionalrelationbetweenthevariables,conceptoferrors,principleofleastsquares,Simplelinear regressionanditsproperties.Fittingoflinearregressionlineandcoefficientofdeterminationtheirinterpretation.Fittingofpolynomialandexponentialcurves.	

References

1. AndersonT.W.andJeremyD.Finn(1996).TheNewStatisticalAnalysisofData,Springer
2. Freedman,D.,Pisani,R.andPurves,R.(2014).Statistics,4thEdition,W.W.Norton&Company.
3. Gupta,S.C.(2018).FundamentalofStatistics,HimalayaPublishingHouse,7thEdition.
4. GuptaS.C.andV.K.Kapoor(2020).FundamentalofMathematicalStatistics,SultanChandandCo.12thEdition.
5. Hogg,R.V.McKeanJ.W.andCraig,A.T(2012).IntroductiontoMathemati calStatistics,Pearson7thEdition.
6. JoaoMendesMoreira,AndreCPLFdeCarvalho,TomasHorvath(2018).GeneralIntrod uctiontoDataAnalytics,Wiley.
7. Johnson,R.A.andBhattacharyya,G.K.(2006).Statistics:Principlesandmethods.5thEditio n,JohnWiley&Sons,New York.
8. Medhi,J.(2005).StatisticalMethods,NewAgeInternational.
9. Ross,S.M.(2014).IntroductiontoProbabilityandStatisticsforEngineersandScientists,5thEdition ,AcademicPress.
10. Tukey,J.W.(1977).ExploratoryDataAnalysis,Addison-WesleyPublishingCo.

Pedagogy

- Thecourseistaughtusingtraditionalchalkandtalkmethodusingproblemsolvingthr oughexamplesandexercises.
- Studentsareencouragedtouseresourcesavailableonopensources.

FormativeAssessment:Total 40marks	
AssessmentOccasion/type	Marks
InternalTest1	15
InternalTest2	15
Assignment/Seminar/ Data Analysis(07marks)+Attendance(3mark s)	10
Total	40

II Semester B.Sc., Minor Statistics

Course Content of Semester–II : STATISTICS -II

CourseTitle: Statistics II	CourseCredits:3
TotalContactHours:42	DurationofESA:3hours
FormativeAssessmentMarks:40	SummativeAssessmentMarks:60

Theory Content of Statistics II	42 hrs
Unit–1:Probability	**14hrs**
Probability: Introduction, random experiments, sample space, events and algebra ofevents.DefinitionsofProbability– classical,statistical,andaxiomatic.ConditionalProbability,lawsofadditionandmultiplication,independentevents,theoremoftotalprobability,Bayes'theoremanditsapplications.	
Unit–2:Randomvariables,MathematicalExpectationandGeneratingFunctions	**14hrs**
Randomvariables:discreteandcontinuousrandomvariables,p.m.f.,p.d.f.andc.d.f.,	

Unit -2: Illustrations and properties of random variables, univariate transformations withillustrations. Mathematical Expectation and Generating Functions: Expectation of single random variables and its properties. Momentsandcumulants,momentgeneratingfunction,cumulantgeneratingfunction,probabilitygeneratingfunctions(p.g.f.).Probabilityinequalities(Markov's and Chebychev's).	
Unit–3:Standard Discrete and Continuous distributions	**14hrs**
Standard discrete probability distributions: Bernolli, Poisson, geometric,discrete uniformnegativebinomial,hypergeometric.Standardcontinuousprobabilitydistributions:uniform,Bet aType-IandType-II,Gamma,normal,exponentialandapplicationsofdiscreteand continuousdistributions.	

References

1. Dudewitz.E.J.andMishra.S.N.(1998).ModernMathematicalStatistics.JohnWiley.
2. GoonA.M.,GuptaM.K.,DasGupta.B.(1991),FundamentalsofStatistics,Vol.I,WorldPress,Calcutta.
3. HoggR,V.,MckeanJ.W,andCraig,A.T(2019).IntroductiontomathematicalStatistics,8th Edition,PearsonEducation,NewDelhi.
4. Hogg,R.V.,Tanis,E.A.andRaoJ.M.(2009).ProbabilityandStatisticalInference,SeventhEdition,PearsonEducation,NewDelhi.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the TheoryofStatistics,3rdEdition.(Reprint),Tata McGraw-HillPub.Co.Ltd.
6. Ross,S.(2002),AFirstCourseinProbability,PrenticeHall.

Pedagogy

- Thecourseistaughtusingtraditionalchalkandtalkmethodusingproblemsolvingthroughexamplesandexercises.
- Studentsareencouragedtouseresourcesavailableonopensources.

FormativeAssessment:Total 40marks	
AssessmentOccasion/type	Marks
InternalTest1	15
InternalTest2	15
Assignment/Seminar/ Data Analysis(7marks)+Attendance(3marks)	10
Total	40

Syllabus for III and IV Semester B.Sc. with Statistics as Minor

III Semester B.Sc.

CourseTitle: **Statistics III**	
Total Contact Hours:42	CourseCredits:03
FormativeAssessmentMarks:40	Duration of ESA/Exam:2hours
SummativeAssessmentMarks:60	

CourseObjectives

Toenablethestudentsto

1. DefineanddescribepropertiesofJoint,Marginalandconditionaldistributionsofvariablesand somekeyconcepts of probabilitytheory.
2. Understanddifferentdiscrete,continuousandsamplingdistributions,propertiesandtheirapplic ations.

Course out comes

Aftercompletion ofthiscoursethe studentswill beable to

1. Solve problems of various analytical environments using different distributions and their properties.
2. Find sampling distributions of functions of random variables and explore their applications

Content of ; Statistics III	**42Hrs**
UNIT1:Distribution of Random Variables(Two-dimensional)	**12 Hrs**
Twodimensionalrandomvariables:Jointdistribution,MarginaldistributionandConditionaldistributio ns of random variables, conditional expectation, covariance, correlation and moments.Distributionoffunctionsofrandomvariablesusingm.g.f.anddistributionfunction.Transform ationofvariable technique (one and two variables). Chebyshev'sinequality-proofanditsuseinapproximatingprobabilities;Convergence in Law and convergence in probability .Statements of Weak Law of Large Numbers; Central Limit theorems – De-Moivre. (Some simple examples)	

UNIT2:ProbabilityDistributions-II	**16 Hrs**
Discretedistributions:Rectangular,Geometric,NegativeBinomial,Hypergeometric,Multinomial-definitionthroughprobabilitymassfunction,mean,variance,moments,p.g.f.,m.g.f.,otherpropertiesand applications. Continuous distributions:Uniform, Gamma, Exponential, Beta (type 1 and type 2), Cauchy,Weibull– definition through probability density function, mean, variance, moments, m.g.f., other properties and applications. Bivariatenormaldistribution-definitionthroughprobabilitydensityfunction,marginalandconditional distribution.	
UNIT3:Sampling Distributions and Simulation	**14Hrs**
Definitions of random sample, parameter and statistic, sampling distribution of sample mean, standard error of sample mean, sampling distribution of sample variance, standard error of sample variance. Definition and derivation of Student t, Chi-square and F-Distribution-their properties, mean and variance. Limiting form of t distribution. Exact sampling distributions: Distribution of sample mean $\bar{x}$ and sample variance S^2 under normality assumption. when sampling from normal population. Assuming the independence of sample mean $\bar{x}$ and sample variance S^2 when sampling from normal population derive the distribution of $\frac{\bar{x}}{\sqrt{\frac{S^2}{n}}}$. Distribution of 1/F. Relationshipbetween t, F and χ^2 distributions. Introduction to simulation. Generation of random observations from Uniform, Exponential, Normal, Binomial, Poisson distributions using R-codes. .	

References

1. GuptaS.C.andV.K.Kapoor(2020),FundamentalofMathematicalStatistics,SultanChandand Co. 12thEdition.
2. Hogg,R.V.McKeanJ.W.andCraig,A.T.(2012),IntroductiontoMathematicalStatistics,Pears on 7thEdition.
3. Hogg,R.V.,Tanis,E.A.andRaoJ.M.(2009),ProbabilityandStatisticalInference,10thEdition, Pearson Education, New Delhi.
4. JayKerns,G.(2010).IntroductiontoProbabilityandStatisticsusingR.1stEdition,Springer.
5. Rohatgi,V.K.andA.K.Md.EhsanesSaleh.(2002).AnIntroductiontoProbabilityTheoryandM athematical Statistics, New York, JohnWiley.
6. Ross,S. M. (2014).Introduction toProbabilityModels. 11thEdition,Elsevierscience.

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Pedagogy

1. Thecourseistaught usingtraditional chalkandtalkmethod usingproblem solvingthroughexamplesand exercises.
2. Studentsareencouragedtouseresourcesavailableonopensources.

IV Semester B.Sc.

Course Title: **Statistics IV**	
Total Contact Hours: 42	Course Credits:03
Formative Assessment Marks: 40	Duration of ESA/Exam: 3 hours
Summative Assessment Marks: 60	

Course Objectives

To enable the students to understand the concepts of

4. Families of distributions, order statistics and their distributions.
5. Estimation, criteria for estimators, methods of estimation, confidence interval.
6. Testing of Hypotheses and its theoretical aspects, large and small sample tests.

Course Outcomes

After completion of the course, the students will be able to

1. Carryout statistical analysis by identifying families of distributions and the use of orderstatistics.
2. To find estimators using different methods of estimation and compare estimators.
3. To carryout statistical inference using different tests of hypotheses under different scenarios.
4. Generate random variables and use these generated random variable for illustration ofconcepts studied in this course.

Theory Paper: Statistics IV

Content of Theory Paper : Statistics IV	42 Hrs
UNIT 1: Point Estimation-I	**14 Hrs**
Families of distributions- location and scale families. Single parameter exponential family. Concept of order statistics, Distribution of maximum and minimum order statistics (with proof) and r^{th} order statistic (without proof). Concepts of estimator and estimate. Criteria for estimators: Unbiasedness, Consistency. Invariance property of consistent estimators. Efficiency and relative efficiency. Mean squared error as a criterion for comparing estimators. Sufficient statistics. Statement of Neyman-Factorization theorem.	
UNIT 2: Point Estimation-II	**12 Hrs**
Fisher information function. Statement of Cramer–Rao inequality and its applications. Minimum Variance Unbiased Estimator and Minimum Variance Bound Estimator. Maximum likelihood and method of moment estimation; Properties of MLE and moment estimators and examples. Method of Scoring	
UNIT 3: Testing of Hypotheses	**16 Hrs**
Statistical hypotheses - null and alternative, Simple and composite hypotheses. Type-I and Type-II errors, test functions. Randomized and non-randomized tests. Size, level of significance, Power function, power of tests. Critical region, p- value and its interpretation. Most Powerful (MP) and UMP test. Statement of Neyman-Pearson Lemma and its applications. Likelihood ratio tests. Large and small samples tests of significance. Tests for single mean, equality of two means, single variance and equality of two variances for normal populations. Tests for proportions. .	

Text Books:

11. 1. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, SultanChand and Co. 12^{th} Edition.

12. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theoryand Mathematical Statistics, New York, John Wiley.

13.

References

14. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R.Wiley.
15. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to MathematicalStatistics, Pearson 7^{th} Edition.
16. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical

Inference, 10thEdition, Pearson Education, New Delhi.

17. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5thEdition, John Wiley & Sons, New York.
18. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa PublishingHouse.
19. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal BookStall.
20. Ross, S.M. (2014), Introduction to Probability and Statistics for Engineers and Scientists,5th Edition, Academic Press.

Pedagogy

3. The course is taught using traditional chalk and talk method using problem solving throughexamples and exercises.
4. Students are encouraged to use resources available on open sources.

Formative Assessment: Total 40 marks	
Assessment Occasion/ type	**Weightage in Marks**
Internal Test 1	15
Internal Test 2	15
Assignment/Seminar (7 marks)+Attendance(3marks)	10
Total	40

Summative Assessment : Total Marks :60			
	Questions to be answered	Marks	Total marks
Part A	Three questions out of Five questions	3x2	06
Part B	Four questions out of Eight questions	4x6	24
Part C	Three questions out of Five questions	3x10	30
Total			60

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