MODEL CURRICULUM FOR THE UNDER-GRADUATE PROGRAMS IN UNIVERSITIES AND COLLEGES OF KARNATAKA

UNDER NATIONAL EDUCATION POLICY-2020

SUBJECT: STATISTICS

(FOR III AND IV SEMESTERS)

JUNE-2022

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Preamble

Several reforms in our education system has been proposed and developed by Ministry of HRD as National Education Policy (NEP)2020 which includes broad based multidisciplinary undergraduate education with necessary knowledge, skills and competencies. It also proposes to bring equity, efficiency and academic excellence at different levels of education. NEP also recommended multidisciplinary undergraduate programmes with multiple exit and multiple entry options with the provision of Certificate/Diploma/Degrees at each of the exits.

Probability and Statistics is the language of uncertainties, riddled modern information age. Statistics facilitates the decision making process by quantifying the element of chance or uncertainties. Its descriptive and inferential procedures not only formulate the basis of the growth of almost all disciplines of the contemporary world, and also provide an array of employment avenues in all fields. This is a rigorous program in Probability Theory , Statistical Inference, Multivariate Analysis, Linear Models and Regression Analysis and Sample surveys and Design of Experiments designed to give a sound foundation in fundamentals and training in practical Statistics leading to statistical data analysis.

The eight semester 176 credit program has a variety of elective courses to choose from including enough courses on statistical software. A person successfully completing the program will have enough knowledge and expertise to statistically analyze small and large univariate and multivariate data sets, pursue advanced courses in Statistics or a Ph.D. in Statistics, work in software/data analytics industry as domain expert, independently consult for statistical data analysis. The program has proved to be one of the best in traditional Indian Universities/Institutes and has demand from students within and outside the State/Country.
In this direction, a committee of subject experts is constituted by Karnataka Higher Education Council (KHEC) to develop model curriculum for subject Statistics.

The subject expert committee consists of

1. Prof. Parameshwar V Pandit (Chairperson)
   Professor and Chairperson, Department of Statistics
   Bangalore University, Bengaluru

2. Dr. B S Biradar
   Professor and Chairperson, Department of Statistics
   Mysore University, Mysuru

3. Dr. Surekha B Munoli
   Professor, Department of Statistics
   Karnataka University, Dharwad.

4. Dr Sujata Inginshetty
   Professor and Chairperson, Department of Statistics
   Gulbarga University, Kalaburgi

5. Dr Deepa Yogesh Kamat
   Head, Associate Professor
   Department of Statistics
   Nrupathunga University, Bengaluru

6. Dr. R Vidya
   Professor, Department of Statistics
   Yuvaraja's College, Mysuru

7. Smt. Revathi Deshmukh
   Associate Professor, GFGC, Bagalkot

8. Dr. Savitha Kumari
   Department of Statistics
   SDM Degree College, Ujire, Dakshina Kannada.

9. Shri Ravindra P Reddy
   Associate Professor, Govt. College, Sedam Road, Kalaburgi.

10. Dr. S R Gani
    Department of Statistics
    Karnataka Arts College, Dharwad.

11. Dr. Tejaswini B Yakkundimath (Member Convener)
    Associate Professor of Economics,
    Government First Grade College for women, Belagavi.

12. Rajani B. (Co Convener)
    Special Officer Karnataka State Higher Education council

The committee acknowledges the support from Karnataka Higher Education Council (KHEC), particularly, the support of Prof. B. Thimmegouda, Honourable Vice-Chairman, KHEC and Dr. Gopal Krishna Joshi, Honourable Executive Director, KHEC. The committee acknowledges the Chairman and members, Faculty Committee for Physical and Mathematical Sciences, KHEC.

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

Bachelor of Science (Basic/Hons.)

With Statistics as Major with practicals and any other subject as minor
(III and IV semesters)

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

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/ Hons.) etc. with Statistics as Major with practicals and any other subject as minor

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)+ Practical (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)		23
II	**Probability and Distributions (4) + Practical (2)** Discipline B2(4+2)	OE-2 (3)	L1-2(3), L2-2 (3) (3+1+0 each)	Environmental Studies (2)		Health and Wellness/ Social & Emotional Learning (2) (1+0+2)	25
Exit option with Certificate (48 credits)							
III	**Calculus and Probability Distributions(4) +Practical (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) + Practical (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)							
Choose any one Discipline as Major, the other as the Minor							
V	**Matrix Algebra and Regression Analysis (3)+Practical (2) Analysis of variance and design of experiments(3)+Practical (2)** Discipline B5(3+2)	Statistics E-1(3:0:0)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Awareness (2) (1+0+2)?	20

VI	**Statistical Inference-II(3)+ Practical (2)** **Sample Surveys and Statistics for National Development (3)+ Practical (2)** Discipline B6(3+2)	Statistics E-2(3:0:0)			SEC-4: Professional/ Societal Communication (2)		20
Exit option with Bachelor of Arts, B.A. / Bachelor of Science, B. Sc. Basic Degree (136 credits)							
VII	**Real Analysis (3)+ Practical (2)** **Probability Theory (4)** **Theory of Estimation(3)+Practical (2)**	Statistics E-3(3:0:0) Res. Methodology (3)					20
VIII	**Linear Algebra (4)** **Testing of hypotheses (4)** **Linear models and Design of Experiments (3)**	Statistics E-4(3:0:0) 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)+ Practical (2)** **Decision Theory and Bayesian Inference (4)** **Distribution Theory (3)+Practical (2)**	Statistics E-5(3:0:0) Research Methodology(3)					20
X	**Stochastic Processes(4)** **Time Series Analysis (3)** **Machine Learning (4)**	Statistics E-6 (3:0:0) 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
	DSC A8	Sample Surveys and Statistics for National Development	3
		Practicals based on DSC A8	2
VII	DSC A9	Real Analysis	3
		Practicals based on DSC A9	2
	DSC A10	Probability Theory	4
	DSC A11	Theory of Estimation	3
		Practicals based on DSC A11	2
VIII	DSC A12	Linear Algebra	4
	DSC A13	Testing of hypotheses	4
	DSC A14	Linear models and Design of Experiments	3

Semester	Course Code	Title of the Paper	Credits
IX	DSC A15	Multivariate Analysis	3
		Practicals based on DSC A15	2
IX	DSC A16	Decision Theory and Bayesian Inference	4
	DSC A17	Distribution Theory	3
		Practicals based on DSC A17	2
X	DSC A18	Stochastic Processes(4)	4
	DSC A19	Time Series Analysis (3)	4
	DSC A20	Machine Learning (4)	3

List of Open Elective (OE) for III and IV semesters

1) Population Studies
2) Survival Models
3) Operations Research
4) Quantitative Analysis Techniques

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))**
Projects	**40**	**60**
Experiential Learning (Internships, etc.)	**40**	**60**

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

Course Title: **Calculus and Probability Distributions**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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, Jacobians. 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. Transformation of variable technique (one and two variables). Chebyshev's inequality- proof and its use in approximating probabilities; Statements of Weak Law of Large Numbers; Convergence in law 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, 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. Exact sampling distributions: Chi square distribution- mean, variance, moments, mode, additive property. Student's and Fisher's t-distribution- mean, variance, moments and limiting form of t distribution. Snedecor's F-distribution: mean, variance and mode. Distribution of 1/F. Relationship between 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. 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. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12th Edition.
4. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference,10th Edition, Pearson Education, New Delhi.
6. Jay Kerns, G. (2010). Introduction to Probability and Statistics using R. 1st Edition, Springer.
7. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
8. Ross, S. M. (2014). Introduction to Probability Models. 11th Edition, Elsevier science.
9. Ross, S. M. (2012). Simulation. Academic Press.
10. Shanthi Narayana (2000), Integral Calculus, S. Chand & Co. Ltd.
11. Shanti Narayana (2000). Differential Calculus, S. Chand & Co. Ltd.
12. 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

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

B.Sc.
IV Semester

Course Title: **Statistical Inference-I**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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- 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.	
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.	

References

1. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R. Wiley.
2. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12^{th} Edition.
3. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7^{th} Edition.

4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
5. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.
6. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa Publishing House.
7. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal Book Stall.
8. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
9. 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

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. Evaluation 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

Model Program Structure for the Under-Graduate Programs in Universities and Colleges of Karnataka

Bachelor of Science (Basic/Hons.)

With Statistics as Minor with practicals and any other subject as major

(III and IV semesters)

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

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/ Hons.) etc. with Statistics as Minor with practicals and any other subject as 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	Discipline A1(4+2) **Descriptive Statistics(4)+ Practical (2)**	OE-1 (3)	L1-1 (3), L2-1(3) (3+1+0 each)		SEC-1: Digital Fluency (2) (1+0+2)		25
II	Discipline A2(4+2) **Probability and Distributions (4) + Practical (2)**	OE-2 (3)	L1-2(3), L2-2 (3) (3+1+0 each)	Environmental Studies (2)		Health and Wellness/ Social & Emotional Learning (2) (1+0+2)	25
Exit option with Certificate (48 credits)							
III	Discipline A3(4+2) **Calculus and Probability Distributions(4) +Practical (2)**	OE-3 (3)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2: Artificial Intelligence (2)(1+0+2)		25
IV	Discipline A4(4+2) **Statistical Inference(4) + Practical (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)							
Choose any one Discipline as Major, the other as the Minor							
V	Discipline A5(3+2) Discipline A6(3+2) **Elements of Multivariate analysis and regression analysis(3) +Practical (2)**	DSE A-1(3:0:0)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Aware-ness (2) (1+0+2)?	20

VI	Discipline A7(3+2) Discipline A8(3+2) **Sample Surveys and Design and Analysis of Experiments(3)+ Practical (2)**	DSEA-2(3:0:0)			SEC-4: Professional/ Societal Communication (2)		20
Exit option with Bachelor of Arts, B.A. / Bachelor of Science, B. Sc. Basic Degree (136 credits)							

Summary of Discipline Specific Courses (DSC)			
Semester	**Course Code**	**Title of the Paper**	**Credits**
I	DSC B1	Descriptive Statistics	4
		Practicals based on DSC B1	2
II	DSC B2	Probability and Distributions	4
		Practicals based on DSC B2	2
III	DSC B3	Calculus and Probability Distributions	4
		Practicals based on DSC B3	2
IV	DSC B4	Statistical Inference	4
		Practicals based on DSC B4	2
V	DSC B5	Elements of Multivariate Analysis and Regression analysis	3
		Practicals based on DSC B5	2
VI	DSC B6	Sample surveys and Design and Analysis of experiments	3
		Practicals based on DSC B6	2

List of Open Elective (OE) for III and IV semesters

1) Population Studies
2) Survival Models
3) Operations Research
4) Quantitative Analysis Techniques

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))**
Projects	**40**	**60**
Experiential Learning (Internships, etc.)	**40**	**60**

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

Course Title: **Calculus and Probability Distributions**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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, Jacobians. 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. Transformation of variable technique (one and two variables). Chebyshev's inequality- proof and its use in approximating probabilities; Statements of Weak Law of Large Numbers; Convergence in law 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, 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. Exact sampling distributions: Chi square distribution- mean, variance, moments, mode, additive property. Student's and Fisher's t-distribution- mean, variance, moments and limiting form of t distribution. Snedecor's F-distribution: mean, variance and mode. Distribution of 1/F. Relationship between 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. 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. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12th Edition.
4. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
6. Jay Kerns, G. (2010). Introduction to Probability and Statistics using R. 1st Edition, Springer.
7. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
8. Ross, S. M. (2014). Introduction to Probability Models. 11th Edition, Elsevier science.
9. Ross, S. M. (2012). Simulation. Academic Press.
10. Shanthi Narayana (2000), Integral Calculus, S. Chand & Co. Ltd.
11. Shanti Narayana (2000). Differential Calculus, S. Chand & Co. Ltd.
12. 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

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

B.Sc.
IV Semester

Course Title: **Statistical Inference-I**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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-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.	
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.	

References

1. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R. Wiley.
2. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12^{th} Edition.
3. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7^{th} Edition.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
5. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.

6. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa Publishing House.
7. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal Book Stall.
8. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
9. 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

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. Evaluation 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

Model Program Structure for the Under-Graduate Programs in Universities and Colleges of Karnataka

Bachelor of Science (Basic/Hons.)

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

(III and IV semesters)

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

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 in 3rd year

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 Inte-elligence (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 Aware-ness (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

List of Open Elective (OE) for III and IV semesters

1) Population Studies
2) Survival Models
3) Operations Research
4) Quantitative Analysis Techniques

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))**
Projects	**40**	**60**
Experiential Learning (Internships, etc.)	**40**	**60**

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

B.Sc.
III Semester

Course Title: **Calculus and Probability Distributions**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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, Jacobians. 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. Transformation of variable technique (one and two variables). Chebyshev's inequality- proof and its use in approximating probabilities; Statements of Weak Law of Large Numbers; Convergence in law 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, 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. Exact sampling distributions: Chi square distribution- mean, variance, moments, mode, additive property. Student's and Fisher's t-distribution- mean, variance, moments and limiting form of t distribution. Snedecor's F-distribution: mean, variance and mode. Distribution of 1/F. Relationship between 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. 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. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12th Edition.
4. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, 10th Edition, Pearson Education, New Delhi.
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8. Ross, S. M. (2014). Introduction to Probability Models. 11th Edition, Elsevier science.
9. Ross, S. M. (2012). Simulation. Academic Press.
10. Shanthi Narayana (2000), Integral Calculus, S. Chand & Co. Ltd.
11. Shanti Narayana (2000). Differential Calculus, S. Chand & Co. Ltd.
12. 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

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

B.Sc.
IV Semester

Course Title: **Statistical Inference-I**	
Total Contact Hours: 56	Course Credits:04
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	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 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.	
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.	

References

1. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling and R. Wiley.
2. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12^{th} Edition.
3. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7^{th} Edition.
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5. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.
6. Kale, B.K. (1999). A First Course on Parametric Inference, New Delhi, Narosa Publishing House.
7. Kendall, M.G., et. al., (1996). An Introduction to the Theory of Statistics, Universal Book Stall.
8. Rohatgi, V.K. and A.K. Md. Ehsanes Saleh. (2002). An Introduction to Probability Theory and Mathematical Statistics, New York, John Wiley.
9. 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

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. Evaluation 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

List of Open Electives (OE)

1) **Population Studies**
2) **Survival Models**
3) **Basics of Operations Research**
4) **Quantitative Analysis Techniques**

1. Population Studies

Course Objectives

1. To enable the students to identify appropriate sources of data, perform basic demographic analysis using various techniques and ensure their comparability across populations.
2. To acquire knowledge about the construction of life table and its applications in demographic analysis.

Course Outcomes (CO)

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

CO1. Study the concepts of Vital Statistics, sources of data, different measures of Fertility, Mortality and migration.

CO2. Understand the Growth rates- GRR and NRR and their interpretations.

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.

Contents

UNIT-1: Introduction and Sources of Population Data **14 hours**

History, definition, nature and scope of population Studies. Sources of population data – salient features of Census, Civil Registration System, National Sample Surveys, Demographic Surveys, relative merits and demerits of these sources. Coverage and content errors. Use of balancing equations, Chandrasekar-Deming formula to check completeness of vital registration data, use of Whipple's, Myer's and UN indices.

UNIT-2 : Fertility, Mortality **14 hours**

Basic concepts and terms used in the study of fertility. Measures of fertility- Crude Birth Rate (CBR), General Fertility Rate (GFR), Age Specific Fertility Rate (ASFR), Total Fertility Rate (TFR), Birth order statistics, Child Women ratio. Measures of reproduction- Gross Reproduction Rate (GRR)and Net Reproduction rate(NRR). Measurement of population growth rate- simple growth rate and compound growth rate.

Basic concepts and terms used in the study of mortality. Measures of mortality- Crude Death Rate (CDR), Age Specific Death Rate (ASDR), Direct and Indirect Standardized Death rates, Infant Mortality Rate (IMR), Under-five mortality Rate, Neo-natal mortality rate, Post-natal mortality rate; Maternal Mortality Rate (MMR).

UNIT-3: Life tables and Population change **14 hours**

Life tables: Components of a life table, force of mortality and expectation of life table, types of life tables. Construction of life tables using Reed-Merrell's method, Greville's method. Uses of life tables.

Basic concepts and definition of population change, migration. Types of migration- internal and international, factors affecting migration. Rates and ratios of Migration-Indirect measures of net-internal migration, national growth rate method, residual method, push-pull factors Population estimates and projections.

References

1. Barclay, G, W(1968). Techniques of Population Analysis, John Wiley and Sons, Incs. New York/London.
2. Keyfitz, H (1968). Introduction to the Mathematics of Population. Addison-Wesley Publishing Co.
3. Pathak, K.B and Ram, F (1991).Techniques of Demographic Analysis, Himalaya Publishing House.
4. Ramakumar. R (1986). Technical Demography, Wiley Eastern Ltd.
5. Srinivasan. K (1998). Basic Demographic Techniques and Applications, Sage Publication, New Delhi.
6. Wunsch G.J. & M.G. Tarmota(1978). Introduction to Demographic Analysis, Plenum Press, N.Y.

2. Survival Models

Course Objectives

1. Enable the students to construct and interpret life tables.
2. To understand the concepts of Survival analysis.
3. To study the design of clinical trials and their analysis.

Course Outcomes:

By the end of this course, the student should be able to:

CO1.Explain Life Tables, types of life tables, its functions, construction.

CO2. Describe multiple decrement life tables and their construction.

CO3. Know survival models, concepts of survival analysis, notion of ageing.

CO4. Explain key concepts in the design of clinical trials, phases, types, clinical trial protocol, analysis.

Content

Unit-1: Life Tables **14 hours**

Basic definition and notations, Types of life tables, inter – relationships between life table functions, Properties of life table functions. Construction of life tables using Reed – merrel and Greville's Method. Competing causes of failure/death, Multiple decrement life tables and their construction (with examples).

Unit-2: Survival Concepts **14 hours**

Life distributions, survival functions, failure rate, Integrated hazard function, residual life time, mean residual life time. Notion of aging: IFR, IFRA, DMRL, NBU, NBUE classes of life distributions and their dual classes. Common Life Distributions: binomial, Poisson, exponential, Weibull, gamma, Pareto and log-normal distributions.

Unit-3: Clinical Trials **14 hours**

Basics of Clinical Trials: Who can be in clinical trials? need clinical trials, Brief History of Clinical Trials, Common Terms in clinical Trials: Clinical Research, Healthy Volunteer, Inclusion/Exclusion Criteria, Informed Consent, Patient Volunteer, Phases of Clinical Trials, Placebo, Protocol, Principal Investigator, Randomization, Single- or Double-Blind, Studies, Types of Clinical Trials. - Diagnostic trials, Natural history studies, Prevention trials, Quality of life trials, Screening trials, Treatment trials, therapeutic trials and prophylactic trials. Observational studies – Cross

sectional studies, prospective studies, retrospective studies, randomized control studies. Clinical Trial Protocol and its components. Type of analyses: ITT, mITT and PP. Odds ratio, Relative risk, Sensitivity, specificity, false negative and false positive rates. Receiver operating characteristic(ROC) curve.

References

1. Deshpande, J V and Purohit, Sudha (2005). Life Time Data: Statistical Models and Methods. World Scientific.
2. Friedman, Furberg, and DeMets. (2010). Fundamentals of Clinical Trials (4th Edition). Springer, Free text available online at http://dx.doi.org/10.1007/978-1-4419-1586-3
3. Lawrence MF, Curt DF, David LD (2010), Fundamentals of clinical trials.
4. R. Ramkumar (1986), Technical Demography, Wiley Eastern, New Delhi.
5. Shryock, Henry S, Jacob S, Siegel and Associates (1964). Methods and materials of demography (condensed edition), Academic press, London.

3. Basics of Operations Research

Course Objectives

1. Students get knowledge about the scope and application of Operations Research(OR) in business and industry.
2. Exposes the students to various OR tools and models.
3. To get knowledge about various decision making through OR models.

Course Outcomes

Students will be able to

CO1- Generate mathematical models of business environment.

CO2-Analyze the business situations.

CO3-Use different solution procedures through OR models.

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.

Contents

Unit-1: Introduction to Operations Research(OR) 14 hours

Origin and growth of OR, importance of OR in managerial decision making, scope and applications of OR, models and modelling in OR. Linear programming problems(LPP): Formulation of the problem, feasible & infeasible, basic feasible solution, optimal, unbounded and multiple optimal solutions of LPP, solution by graphical method. Slack, Surplus and Artificial variables. Duality in LPP, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality.

Unit-2: Allocation Problems 14 hours

Transportation problems: Formulation, methods of finding initial solution (North West Corner Rule, Least Cost Method and Vogel's Approximation Method), unbalanced transportation problems, maximization transportation problem.

Assignment problems: Formulation, methods of solution, Hungarian method, multiple optimal solutions, unbalanced problems, maximization problems.

Unit-3: Decision theory **14 hours**

Game theory: Basic concepts. Two – Person Zero Sum Game. Pure and Mixed Strategies. Maximin – Minimax principle, Games with and without saddle points. Principle of dominance.

Concepts of decision making, decision making environments, Decision making under uncertainty - Decision making under risk, decision tree analysis. Case discussion.

Concepts of network analysis, project network models, Critical Path Method, PERT.

References

1. Hillier, F S, et al. Introduction to Operations Research (9/e). Tata McGraw Hill, 2011.
2. Ravindran, A and Don T Phillips. Operations Research: Principles and Practice. John Wiley & Sons, 1987.
3. Sharma, J K. Operations Research: Theory and Applications (5/e). New Delhi: Laxmi Publications, 2013.
4. Taha, Hamdy A. Operations Research: An Introduction (9/e). Prentice Hall, 2010.
5. Vohra, N D. Quantitative Techniques for Management. Tata McGraw Hill Education, 2015.
6. Kanti Swarup, Gupta, P.K. and Man Mohan: Operations Research, Sultan Chand & Sons, New Delhi.
7. Kapoor, V.K: Operations Research, Sultan Chand & Sons, New Delhi.
8. Kapoor, V.K.: Operations Research Problems & Solutions, Sultan Chand & Sons, New Delhi.

4. Quantitative Analysis Techniques

Course Objectives

To enable the students to acquire the knowledge about

1. The concepts of correlation and regression analysis.
2. The concepts of linear programming problem and its applications.
3. The students will learn the tools of data mining.

Course Outcomes

Students will be able to

CO1. Carryout correlation and regression analysis.

CO2. Formulate and solve linear programming problems.

CO3. Use data mining tools.

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.

UNIT- 1: Correlation and regression analysis **14 hours**

Correlation- Definition, Types - Simple, multiple, partial. Causation - Spurious, positive, negative, perfect and no correlation, explanation with examples. Importance of correlation analysis. Measurement of correlation- scatter diagram, Karl Pearson's coefficient of correlation, Properties of coefficient of correlation, interpretation. Spearman's coefficient of rank correlation – with and without ties, interpretation. Coefficient of determination and its interpretation.

Regression- Definition, regression lines/equations of X on Y and Y on X. Properties of regression coefficients and regression lines/equations. Principle of least squares and fitting of linear, quadratic and exponential curves. Uses of regression analysis. Comparison between correlation and regression.

UNIT-2: Linear programming problem(LPP) **18 hours**

Definition and scope of Operations Research (OR). Modelling and solution. Linear Programming

Problem (L.P.P): Definition, Standard forms. Formulation of LPP. Basic Solutions, degenerate and non-degenerate solutions. Graphical method of solving LPP. Criteria for unbounded, Multiple and infeasible solutions.

Transportation problem: Mathematical formulation. Existence of feasible solution. Finding initial basic feasible solution: North West Corner Rule, matrix minima method and Vogel's method. Unbalanced transportation problem.

Assignment Problem: Mathematical Formulation and Hungarian algorithm. Unbalanced assignment problem.

UNIT-3: Data Mining **10 hours**

Motivations and importance of Knowledge Discovery in Databases (KDD) process - search, induction, querying, approximation and compression. Kinds of data considered for data mining, basic data mining tasks, data mining issues, Data Mining models - predictive and descriptive, interconnections between Statistics and Data Mining. Artificial Intelligence and Machine Learning. Applications of data mining.

References

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. I, 8th Ed., The World Press, Kolkata.
2. Ross, S.M. (2014). Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press.
3. Kanthi Swaroop, Manmohan and P. K. Gupta (2013). Operation Research, Sultan Chand New Delhi.
4. Mustafi, C. K. (2006). Operations Research Methods and Practice, 3/e. New Age Publication.
5. Narag. A. S. (1970). Linear Programming and Decision Making. Sultan Chand and Co.
6. Sharma, J K.(2013). Operations Research: Theory and Applications (5/e). New Delhi: Laxmi Publications.
7. Jiawei Han, Micheline Kamber (2002). Data mining concepts and Techniques, Morgan Kaufman Publishers, USA.
8. Trevor Hastie, Robert Tibshirani and Jerome Friedman (2001). The elements of Statistical learning: Data Mining, Inference and Prediction, Springer, New York.
9. Rajan Chattamvelli (2009). Data mining methods, Narosa Publishing House.

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

Bachelor of Arts (Basic/Hons.)

With Applied Statistics as Minor without practicals & other course as Major without practicals
(III and IV semesters)

And

Bachelor of Arts (Basic/ Hons.)

With Applied Statistics as Minor without practicals & other course as Major with practicals
(III and IV semesters)

Name of the Degree Program: B.A

Discipline Core: Applied Statistics

Total Credits for the Program: 136(till 6th semesters)

Starting year of implementation: 2021-22

Assessment

Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40	60
Practical	Not applicable	Not applicable
Projects	Not applicable	Not applicable
Experiential Learning (Internships etc.)	Not applicable	Not applicable

Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka
Bachelor of Arts (Basic/Hons.)
With Applied Statistics as Minor without practicals &other course as Major without practicals

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	Discipline A1(3), A2(3) **Applied Statistics** B1(3), B2(3)	OE-1 (3)	L1-1 (3), L2-1(3) (3+1+0 each)		SEC-1: Digital Fluency (2) (1+0+2)		25
II	Discipline A3(3), A4(3) **Applied Statistics** B3(3), B4(3)	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	Discipline A5(3), A6(3) **Applied Statistics** B5(3), B6(3)	OE-3 (3)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2:Artificial Intel-ligence (2)(1+0+2)		25
IV	Discipline A7(3), A8(3) **Applied Statistics** B7(3), B8(3)	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)/ Choose any one Discipline as Major, the other as the Minor							
V	Discipline A 9(4) Discipline A10(4) **Applied Statistics** B 9(4)	DSE A-1 (3) Vocational-1 (3)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Awareness (2) (1+0+2)	20
VI	Discipline A11(4) Discipline A12(4) **Applied Statistics** B10(4)	DSE A-2 (3) Vocational-2 (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)							
VII	Discipline A-13(4) Discipline A-14(4) Discipline A-15(3)	DSE A-3 (3) DSE A-4 (3) Res.Methodology (3)					20
VIII	Discipline A-16(4) Discipline A-17(4) Discipline A-18(3)	DSE A-5 (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)							

*In lieu of the research Project, two additional elective papers/ Internship may be offered.

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

Bachelor of Arts (Basic/ Hons.)

With Applied Statistics as Minor without practicals & other course as Major with practicals

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	Discipline A1(4+2) **Applied Statistics** B1(3), B2(3)	OE-1 (3)	L1-1 (3), L2-1(3) (3+1+0 each)		SEC-1: Digital Fluency (2) (1+0+2)		25
II	Discipline A2(4+2) **Applied Statistics** B3(3), B4(3)	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	Discipline A3(4+2) **Applied Statistics** B5(3), B6(3)	OE-3 (3)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2:Artificial Intel-ligence (2)(1+0+2)		25
IV	Discipline A4(4+2) **Applied Statistics** B7(3), B8(3)	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)/ Choose any one Discipline as Major, the other as the Minor							
V	Discipline A 5(3), A6(3) Discipline A 7(2)(P) **Applied Statistics** B 9(4)	DSE A-1 (3) Vocational-1 (3)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Aware-ness (2) (1+0+2)?	20
VI	Discipline A 8(3), A9(3) Discipline A10(2)(P) **Applied Statistics** B10(4)	DSE A-2 (3) Vocational-2 (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)							
VII	Discipline A11(3), A12(3) Discipline A13(3) Discipline A14(2)(P)	DSE A-3 (3) DSE A-4 (3) Res.Methodology (3)					20
VIII	Discipline A15(3), A16(3) Discipline A17(3) Discipline A18(2)(P)	DSE A-5 (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)							

Summary of Discipline Specific Courses (DSC)		
Semester	**Course Code**	**Title of the Paper**
I	DSC B1	Descriptive Statistics – I
	DSC B2	Descriptive Statistics –II
II	DSC B3	Probability and Distributions
	DSC B4	Statistics for Economics
III	DSC B5	Exact Sampling Distributions and Statistical Inference
	DSC B6	Sampling Techniques
IV	DSC B7	Analysis of variance and Design of Experiments
	DSC B8	Regression Analysis and Econometrics
V	DSC B9	Statistical Quality Control
VI	DSC B10	Operations Research

Open Electives

III Semester	OE	Data Analysis with SPSS
IV Semester	OE	Demography

B.A. Semester III

Title of the Course: Applied Statistics

Course 5: **Exact Sampling Distributions and Statistical Inference**		Course 6: **Sampling Techniques**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester
3	42	3	42

Course 3: Exact Sampling Distributions and Statistical Inference	
Total Contact Hours: 42	Course Credits:03
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	Summative Assessment Marks: 60

Course Objectives:

1. Use of sampling distribution of mean and proportion to draw inferences about the population mean and population proportion.
2. Calculate the error in sampling using sampling distribution.
3. Methods of estimation of parameters.
4. Comparison between the various types of estimators.
5. Applications of parametric tests on various standard probability distributions

Course Outcomes:

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

1. Apply different methods of estimations to real life data sets.
2. Basic concepts involved in Tests of Significance and Testing of Hypothesis.
3. Formulate null and alternative hypotheses and apply small, large sample and parametric tests in real life problems.
4. Perform large sample and small sample tests of hypotheses.
5. Apply Chi-square, t and F tests in real life problems.

Content of Course 5: Exact Sampling Distributions and Statistical Inference	42 Hours
UNIT-1: Sampling distribution and Estimation Theory	**20 Hours**
Definition of basic concepts: population, sample, parameter and statistic. Definition of a Random Sample, Sampling distribution of a Statistic along with examples Definition of standard error, Standard error of mean, standard deviation, proportion, difference of means and difference of proportions. Uses of standard error and simple problems. Definition of the terms – Estimate, Estimation, Point estimation and interval estimation. Meaning of confidence interval, confidence limits and confidence co-efficient with examples. Construction of 95% and 99% confidence intervals - mean, difference of means, proportion and difference of proportions for large samples only and their numerical problems on the construction of 95% and 99% confidence limits.	
UNIT-2: Testing of Hypothesis	**10 Hours**
Explanation of terms – Statistical hypothesis, Null hypothesis, Alternative hypothesis, Level of significance, critical region, size of the test, power of the test with examples. Definition of type–I and type–II errors. Large sample tests- Test of significance of population mean, test of significance of equality of means of two populations, test of significance of population proportion and test of significance of equality proportion of two populations.	
UNIT-3: Chi-Square, *t* - test and F-test Distributions	**12 Hours**
Introduction to Chi-square distribution, definition of Chi-square variate. Properties of Chi-square distribution. Applications of Chi-square distribution. Chi-square test of goodness of fit. Problems on Chi-square test of Goodness of fit and independence of attributes. Definition, assumption and properties of t-test. t-test for testing population mean, equality of sample means and paired t-test. Applications of t-test. Simple problems. Definition, assumption and properties of F-statistic. F-test for equality of variances and its applications. Numerical problems.	

References

1. Ramchandran, K.M. and Tsokos C. P. (2009). Mathematical Statistics with Applications, Academic Press.
2. Gupta S. P. (2021). Statistical Methods, Sultan Chand and Sons, New Delhi, 46th edition.
3. Mukhopadhaya, P. (2011). Applied Statistics, Books and Allied Ltd.
4. Gupta, S C. and V. K. Kapoor. (2018). Fundamentals of Mathematical Statistics, Sultan Chand, New Delhi, 11th Edition.
5. Gani S. G.(2003). Sankhyshastra and Ganakayantra, Udaya Ravi Publications, Bijapur.

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

Course 6: Sampling Techniques	
Total Contact Hours: 42	Course Credits:03
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	Summative Assessment Marks: 60

Course Objectives:

1. Obtain the maximum information about the population parameters on the basis of sample.
2. Find the reliability of the estimates derived from the sample (standard error of the statistic).
3. Determine the suitability of the sampling methods in real life situations.

Course Outcomes:

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

1. Concept of Population, Sample, Sampling unit, sampling design, sampling frame, sampling scheme, need for sampling.
2. Apply the different sampling methods for designing and selecting a sample from a population.
3. Design good questionnaire relevant to a survey for a specific investigation.
4. Explain sampling and non-sampling errors.

Content of Course 6: Sampling Techniques	42 Hours
UNIT-1: Basic Concepts of Sampling	**08 Hours**
Meaning of population, population size, finite population, infinite population, sample, sample size, sampling, sampling technique, sampling unit, sampling frame, census and sample survey, advantages of sampling. Examples of sampling. Types of errors in sample survey-Sampling errors and non-sampling errors, non response errors, response errors and tabulation errors. Advantages of sampling over complete census. Limitation of sampling. Planning of sample survey and its execution.	
UNIT-2: Simple Random Sampling	**14 Hours**
Introduction and Definition of Simple Random Sampling (SRS), Notations and formulae for estimating population mean, total and variance. Methods of obtaining simple random sample-Lottery method and Random numbers table method. Merits and demerits of Simple Random Sampling. Simple problems on simple random sampling method.	

UNIT-3: Stratified Random and Systematic Random Sampling Techniques	20 Hours
Need for stratification, stratifying factors, improvement of method over SRS, Definition of strata, stratification, and stratified random sampling. Notations and formulae for estimating population mean, total and variance. Methods of allocation and sample size in different strata-Equal allocation, Proportional allocation and Optimal allocation. Determination of Bowley's formulae for proportional allocation and Neyman's formula for optimal allocation. Advantages and disadvantages of stratified random sampling method. Simple problems on stratified random sampling method, Proportional and Optimal allocation. Definition of systematic random sampling. Explanation of methods of obtaining systematic random samples. Examples of systematic random sample. Formulae for estimating population mean, total and variance. Applications of systematic random sampling method. Merits and demerits of systematic random sampling method. Simple problems on systematic random sampling method.	

References

1. Parimal Mukhopadhyay (2008). Theory and methods of Survey Sampling, PHI publications.
2. Gupta S. P. (2021). Statistical Methods, Sultan Chand and Sons, New Delhi, 46th edition.
3. Gupta S. C. and V. K. Kapoor (2018). Fundamentals of Applied Statistics, Sultan Chand, New Delhi
4. Gani S. G.(2003). Sankhyshastra and Ganakayantra. Udaya Ravi Publications, Bijapur.

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

B.A. Semester IV

Title of the Course: Applied Statistics

Course 7: **Analysis of Variance and Design of Experiments**		Course 8: **Regression Analysis and Econometrics**	
Number of Theory Credits	Number of lecture hours/semester	Number of Theory Credits	Number of lecture hours/semester
3	42	3	42

Course 7: Analysis of Variance and Design of Experiments	
Total Contact Hours: 42	Course Credits:03
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	Summative Assessment Marks: 60

Course Objectives:

1. The main objective of this course is to introduce the basic concepts of design of experiments.
2. After successfully completion of this course students are expected to plan and conduct experiments.
3. To identify significant factors in the experiment

Course Outcomes:

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

1. Develop strategic plans for experimentation in scientific research projects,
2. Apply the principles of Design of Experiment to generate experimental designs,
3. Develop problem solving skills for the application of Design of experiments to Agriculture and controlled laboratory experiments.

Content of Course 7: Analysis of Variance and Design of Experiments	**42 Hours**
UNIT-1: Analysis of Variance: One-Way and Two-way Classification	**18 Hours**
Definition of analysis of variance and its basic assumptions. Meaning of assignable and chance variations. ANOVA for one-way classified data-definition, linear mathematical model, assumptions, statement of hypothesis, splitting up of total sum of squares into various component sum of squares, degrees of freedom and ANOVA table. Simple numerical problems one-way classified data. Analysis of variance for two-way classification – definition, linear mathematical	

model, assumptions, statement of hypothesis, splitting up of total sum of squares into various component sum of squares. Degrees of freedom and ANOVA table. Simple numerical problems on two way classified data.	
UNIT-2: Design of Experiments: Completely Randomized Design	**12 Hours**
Definition of terms - Experiment, treatment, experimental unit, experimental material, yield, block, precision, experimental error, uniformity trails, and efficiency. Basic principles of design of experiments - Replication Randomization and Local control. Completely Randomized Design (CRD) -definition, layout, linear mathematical model, assumptions, hypothesis, splitting up of sum of squares into various component sum of squares, degrees of freedom and ANOVA table. Merits, demerits and applications of CRD. Simple numerical problems.	
UNIT-3: Randomized Block Design	**12 Hours**
Introduction and definition of Randomized Block Design (RBD), layout, linear mathematical model, assumptions, statistical hypothesis, splitting up of total sum of squares into various component sum of squares, degree of freedom, and ANOVA table. Merits and demerits of RBD. Applications of RBD. Comparison between CRD and RBD. Simple problems.	

References

1. Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pvt. Ltd. Kolkatta.
3. Gupta S. P. (2021). Statistical Methods, Sultan Chand and Sons, New Delhi, 46th edition.
4. Gupta S. C. and V. K. Kapoor (2018). Fundamentals of Applied Statistics, Sultan Chand, New Delhi.
5. Mukhopadhaya, P. (2011). Applied Statistics, Books and Allied Ltd.
6. Gani S. G.(2003). Sankhyshastra and Ganakayantra. Udaya Ravi Publications, Bijapur.

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

Course 8: **Regression Analysis and Econometrics**	
Total Contact Hours: 42	Course Credits:03
Formative Assessment Marks: 40	Duration of ESA/Exam: 2 hours
Model Syllabus Authors: State level NEP-model curriculum setting committee members-Statistics	Summative Assessment Marks: 60

Course Objectives

By the end of this course, students will be able to

1. Understand the nature and scope of econometrics as a social science.
2. Use statistical analysis, including the classical regression model, to estimate relevant economic parameters, predict economic outcomes, and test economic hypotheses using quantitative data.
3. Understand the basic assumptions of the classical linear regression model, and identify and correct (if possible) any violations of these assumptions, such as autocorrelation and heteroscedasticity.
4. Develop and maintain a working knowledge of econometrics that will provide a basic foundation for future study in econometrics and statistical techniques.

Course Outcomes

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

1. To provide a wider and deeper exposure to the econometric techniques and their application to the discipline of Economics.
2. To help students gain an understanding of how to solve problems using econometrics that are common to economic modeling.
3. To help in developing the ability to accurately translate complex economic problems into models and so as to solve them by applying econometric techniques.

Content of Course 8: Regression Analysis and Econometrics	**42 Hours**
UNIT-1: Introduction to Econometrics and Simple Regression Analysis	**18 Hours**
Econometrics – definitions – scope – methodology – types. Quantification of hypothetical linear relationship using appropriate data. Two variable regression model, assumptions, method of least squares properties. An optimality property of OLS: Gauss-Markov theorem, R-square, maximum likelihood method, testing of hypotheses using point and interval estimates, forecasting solving problems using SPSS.	

UNIT-2: Multiple Regression Analysis	**12 Hours**
Nonlinear relationships – transformation of variables – functional forms – three variable regression model – applications using SPSS. General linear model (matrix approach) – specification – OLS estimators –The properties of the estimated regression coefficients, hypothesis testing and the construction of confidence intervals of the regression model, problems and application using SPSS.	
UNIT-3: Problems in regression analysis	**12 Hours**
Violation of classical assumptions – multicollinearity – autocorrelation – hetroscedasticity – problems – causes – consequences – remedial measures – model specification and diagnostic testing.	

References

1. Damodar N. Gujarathi (2009). Basic Econometrics, New Delhi: Tata McGraw Hill
2. Companies 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
5. G.M.K. Madanani (1980). Introduction to Econometrics, second edition, Oxford & IBH Publishing company, New Delhi.
6. Gupta, S.C. and Kapoor, V. K. (2020). Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.

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

Data Analysis with SPSS(OE)

Course Objectives

1. To enable the students to use SPSS software for cleaning and presenting the data.
2. To enable the students to construct diagrams and graphs using SPSS.
3. To enable the students to analyze univariate, bivariate and multivariate data using SPSS.

Course Outcomes (CO)

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

CO1. Use SPSS software for cleaning and presentation of data.

CO2. Present the data in the form of diagrams and graphs.

CO3. Analyze univariate, bivariate and multivariate data.

UNIT-1: Introduction **18 hours**

Need of SPSS, preparation of coding sheet of the questionnaire, defining the type of variable and data, constructing the database – defining variable name, type of variable, width of variable name, labeling, assigning the numeric value to the characteristic, declare measurement of scale of data.

Data Editing in SPSS: Enter the data based on type of data case wise for different variables, defining the grouping of variable for repeated measures. Replacing the missing value, transforming the data into same variable and different variable, use of commands –Compute variables using different operators and functions and saving of the data.

UNIT-2: Tabulation and Graphical representation **12 hours**

Formation of frequency distribution, representation of frequency distribution by graphs, construction cross table, P-P plots and Q-Q Plots.

UNIT-3: Univariate, Bivariate and multivariate Data analysis **12 Hours**

Calculation of Measures of central tendency, Dispersion, Karl-Pearson's correlation, Regression, fitting different curves, testing of hypothesis- t-test for single mean, difference of means for independent samples, paired sample and one-way ANOVA.

Note: Various techniques studied in the paper has to be demonstrated using SPSS software.

References

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig (2007). Introduction to Mathematical Statistics, Pearson Education, Asia.

2. Irwin Miller and Marylees Miller, John E. Freunds (2006). Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia.
3. Sheldon Ross (2007). Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint.
4. Gardener, M (2012). Beginning R: The Statistical Programming Language, Wiley Publications.
5. Cunningham, B.J (2012). Using SPSS: An Interactive Hands-on approach.

Demography(OE)

Course Objectives

1. To enable the students to identify appropriate sources of data, perform basic demographic analysis using various techniques and ensure their comparability across populations.

2. To acquire knowledge about the construction of life table and its applications in demographic analysis.

Course Outcomes (CO)

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

CO1. Study the concepts of Vital Statistics, sources of data, different measures of Fertility, Mortality and migration.

CO2. Understand the Growth rates- GRR and NRR and their interpretations.

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.

Contents

UNIT-1 Introduction and Sources of Population Data 14 hours

History, definition, nature and scope of population Studies. Sources of population data – salient features of Census, Civil Registration System, National Sample Surveys, Demographic Surveys, relative merits and demerits of these sources. Coverage and content errors. Use of balancing equations, Chandrasekar-Deming formula to check completeness of vital registration data, use of Whipple's, Myer's and UN indices.

UNIT-2 Fertility, Mortality 14 hours

Basic concepts and terms used in the study of fertility. Measures of fertility- Crude Birth Rate (CBR), General Fertility Rate (GFR), Age Specific Fertility Rate (ASFR), Total Fertility Rate (TFR), Birth order statistics, Child Women ratio. Measures of reproduction- Gross reproduction Rate (GRR)and Net Reproduction rate(NRR). Measurement of population growth rate- simple growth rate and compound growth rate.

Basic concepts and terms used in the study of mortality. Measures of mortality- Crude Death Rate (CDR), Age Specific Death Rate (ASDR), Direct and Indirect Standardized Death rates, Infant Mortality Rate (IMR), Under-five mortality Rate, Neo-natal mortality rate, Post-natal mortality

rate; Maternal Mortality Rate (MMR).

UNIT-3:Life tables and Population change **14 hours**

Life tables: Components of a life table, force of mortality and expectation of life table, types of life tables. Construction of life tables using Reed-Merrell's method, Greville's method. Uses of life tables.

Basic concepts and definition of population change, migration. Types of migration- internal and international, factors affecting migration. Rates and ratios of Migration-Indirect measures of net-internal migration, national growth rate method, residual method, push-pull factors Population estimates and projections.

References

1. Barclay, G, W(1968). Techniques of Population Analysis, John Wiley and Sons, Incs. New York/London.

2. Keyfitz, H (1968). Introduction to the Mathematics of Population. Addison-Wesley Publishing Co.

3. Pathak,K.B andRam,F (1991).Techniques of Demographic Analysis, Himalaya Publishing House.

4. Ramakumar.R (1986). Technical Demography, Wiley Eastern Ltd.

5. Srinivasan.K (1998). Basic Demographic Techniques and Applications, Sage Publication, New Delhi.

6. Wunsch G.J. & M.G. Tarmota(1978). Introduction to Demographic Analysis, Plenum Press, N.Y.