UNIVERSITY OF KERALA

SYLLABUS IN OUTCOME-BASED EDUCATION MODE

FOR

FIRST DEGREE PROGRAMME IN STATISTICS

(BSc)

UNDER CHOICE BASED

CREDIT AND SEMESTER SYSTEM

(CBCSS)

2022 ADMISSION ONWARDS

UNIVERSITY OF KERALA

FIRST DEGREE PROGRAMME IN STATISTICS

CHOICE BASED CREDIT AND SEMESTER SYSTEM

EFECTIVE FROM 2022 ADMISSIONS

(Revised)

Aims and Objectives of the Programme

Aims:

The aim of the programme is to provide a solid foundation in all aspects of Statistics and to show a broad spectrum of modern trends in Statistics and to develop experimental, computational and application skills of students. The syllabus is framed in such a way that it bridges the gap between the higher secondary and post graduate levels of Statistics by providing a more complete and logical framework in almost all areas of basic Statistics. The new, updated syllabus is in accordance with the paradigm of outcome-based education (OBE). The programme also aims at:

(i) providing education in Statistics of the highest quality at the undergraduate level and produce graduates of the calibre sought by industries and public service as well as academic teachers and researchers of the future.

(ii) attracting outstanding students from all backgrounds.

(iii) providing an intellectually stimulating environment in which the students have the opportunity to develop their skills and enthusiasms to the best of their potential.

(iv) maintaining the highest academic standards in undergraduate teaching.

(v) imparting the skills required to gather information from resources and use them.

(vi) equipping the students with methodologies related to Statistics.

Objectives:

By the end of the second semester, the students should have:

(i) attained a common level in elementary and basic principles of Statistics and laid a strong foundation in Mathematics for their future courses.

(ii) developed their experimental and data analysis skills through a wide range of expertise in handling applications of Statistics by their training acquired in the statistics lab.

By the end of the fourth semester, the students should have:

(i) been introduced to powerful tools for tackling a wide range of topics in statistical methods and distribution theories

(iii) become familiar with additional relevant mathematical techniques.

(iv) further developed their experimental skills through a series of practical training imparted in the statistical lab, which is an integral part of the proposed new curriculum.

By the end of the sixth semester, the student should have.

(i) covered a range of topics in almost all areas of Statistics including a statistical inference, sample survey, design of experiments, operations research, statistical quality control and other applied areas.

(ii) had expertise and independence in handling real life applications of Statistics as demonstrated in their project work.

(iii) developed their understanding of Statistics as an important branch of science having applications in all areas of learning.

Course Structure:

Sem	Course title	Instructional Hours / week		Credit	Total Hours / Semester	Evaluation weightage	
		L	P			Internal	External
I	ST 1141 Statistical Methods I	2	2	4	72	20%	80%
II	ST 1241 Statistical Methods II (Foundation course 2)	2	2	3	72	20%	80%
III	ST 1341 Probability and Distributions-I	3	2	3	90	20%	80%
IV	ST 1441 Probability and Distributions-II ST 1442 Practical I	3	2	3 3	54 36	20%	80%
V	ST:1541 Limit Theorems and Sampling Distributions	3	2	4	90	20%	80%
	ST 1542 Estimation	3	2	3	90		
	ST 1543 Testing of Hypothesis	3	2	3	90		
	ST 1544 Sample Survey Methods	3	2	4	90		
	ST 1551 Open Course 1	3		2	54		
	Project		2	-	36		
VI	ST 1641Design of Experiments and Vital Statistics	4	3	4	126	20%	80%
	ST 1642 Applied Statistics	4	2	4	108		
	ST 1643 Operations Research and Statistical Quality Control	4	2	4	108		
	ST 1644 Practical II			4			
	ST 1645Practical III			3			
	ST 1646 Project		3	4	54		
	ST 1661 Open Course 2 (Elective)	3		2	54		

L – Lecture, P – Practical (Lab). For Practical hours, there shall be one faculty member in charge of every 16 students (based on sanctioned strength) in accordance with University regulations.

Course Structure for Practical courses and Project for the Core Course

Sem	Title of the Paper	Duration of Exam	No. of credits	Evaluation weightage		Allotted hours Per week
				I.A.	E. A.	
IV	ST:1442 Practical I	2 hrs	3	1	3	S_1/ S_2 - 2 S_3/S_4 - 2
VI	ST:1644 Practical II	2 hrs	4	1	3	S_5 - 8
	ST:1645Practical III	2 hrs	3	1	3	S_6 - 7
	ST:1646 Project		4	1	3	S_5 - 2 S_6 - 3

I. A. – Internal Assessment; E. A. – External Assessment.

Project/Internship: In Semesters V and VI, students shall carry out a Project or Internship, which the College may choose according to the infrastructure facilities available and convenience. In either case a duly certified Report shall be submitted to the University for evaluation.

General Course Structure of the First Degree Programme in Statistics

B.Sc. Statistics Degree Programme

I Semester- Core Course 1

ST 1141: Statistical Methods I

Hours/Week: 4

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Describe origin and meaning of Statistics, its uses and relation with other disciplines and its limitations and misuses

CO.2: Describe methods of collection of primary data and sources of secondary data

CO.3: Design a questionnaire and a schedule

CO.4: Classify and tabulate data

CO.5: Diagrammatically represent data through line diagram, bar diagrams, pie diagrams, pictograms, cartograms and graphically represent frequency distribution by frequency polygon, frequency curve and ogives

CO.6: Learn measures of central tendency and measures of dispersion, describe their properties

CO.7: Learn positional averages – quartiles, deciles and percentiles

CO.8: Learn moments - raw and central moments and their inter-relationships and describe Sheppard's corrections for moments for grouped data

CO.9: Describe skewness and kurtosis and learn various measures of them

CO.10:Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO 1.1 Describe origin and meaning of Statistics: General uses, relation with other disciplines	Remember
	MO 1.2 Describe limitations and misuses of Statistics	Remember

	MO 1.3	Describe different scales of measurement	Understand
	MO 1.4	Describe methods of collection of primary data	Understand
	MO 1.5	Describe sources of secondary data	Understand
	MO 1.6	Classify and tabulate a given data	Analyze
Module: II	MO 2.1	Diagrammatically present line diagram, bar diagrams and pie diagrams	Understand
	MO 2.2	Diagrammatically represent data through pictograms, cartograms	Understand
	MO 2.3	Graphically represent frequency distribution by frequency polygon, frequency curve and ogives	Apply
Module:III	MO 3.1	Demonstrate measures of central tendency- arithmetic mean, weighted arithmetic mean, median, mode, geometric mean, harmonic mean	Apply
	MO 3.2	Describe properties of these averages	Understand
	MO 3.3	Describe positional averages such as quartiles, deciles and percentiles	Understand
Module: IV	MO 4.1	Describe measures of dispersion- range, quartile deviation, mean deviation, standard deviation	Apply
	MO 4.2	Explain properties of these measures	Understand
	MO 4.3	Describe coefficient of variation as a measure of relative measure of dispersion	Analyze
Module: V	MO 5.1	Describe raw and central moments	Understand
	MO 5.2	Explain interrelationships - raw and central moments	Apply
	MO 5.3	Describe Sheppard's corrections for moments for grouped data	Understand
	MO 5.4	Define of skewness and kurtosis	Understand
	MO 5.5	Demonstrate measures of skewness and kurtosis	Apply
Module: VI (for practical exam only)	MO 6.1	Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Origin and meaning of Statistics: General uses, relation with other disciplines, Limitations and misuses of Statistics, Different scales of measurement, Methods of collection of primary data. Designing of a questionnaire and a schedule. Sources of secondary data. editing of data, Classification and tabulation of data

Module II Diagrammatic presentation- line diagram, bar diagrams and pie diagrams. Diagrammatic representation of data, pictograms, cartograms etc., Graphical representation of frequency distribution by frequency polygon, frequency curve and ogives

Module III Measures of central tendency-arithmetic mean, weighted arithmetic mean, median, mode, geometric mean, harmonic mean. Properties of these averages. Positional averages – quartiles, deciles and percentiles.

Module IV Measures of dispersion- range, quartile deviation, mean deviation, standard deviation. Properties of these measures. Relative measures of dispersion – coefficient of variation.

Module V Moments - raw and central moments and their interrelationships, Sheppard's corrections for moments for grouped data. Definition and measures of skewness and kurtosis.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References:

1. Anderson, T.W. and Sclove, S. L. (1978). *An Introduction to Statistical Analysis of Data*. Houghton Miffin/co, USA.
2. Anderson, T.W. and Finn, J.D. (2012). *The New Statistical Analysis of Data*. Springer Science & Business Media, New York.
3. Croxton, F.E. and Cowden, D.J. (1973). *Applied General Statistics*. Prentice Hall of India, New Delhi.
4. Gupta S.C. and Kapoor, V.K. (1984). *Fundamentals of Mathematical Statistics*. Sultan Chand & Co., 3rd Edn, New Delhi.

5. Kendall, M.G. (1943). *Advanced Theory of Statistics Vol-I*. Charles Griffin: London.
6. Saxena, H.C. (1983). *Elementary Statistics*. S. Chand & Co., New Delhi.
7. Snedecor, G.W. and Cochran, W.G. (1967). *Statistical methods*. Iowa State University Press, United States.
8. Spiegel, M. R. (1961). *Theory and Problems of Statistics*. Schaum's outline series, New York.
9. Yule, G.U. and Kendall, M.G. (1956). *Theory and Problems of Statistics*. Charles Griffin, London.

II Semester- Core Course 2

ST 1241: Statistical Methods - II

Hours/Week: 5

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Describe the concept of correlation and compute Karl Pearson's correlation coefficient and Spearman's rank correlation coefficient.

CO.2: Discuss partial and multiple regressions for three variables.

CO.3: Describe the concepts of curve fitting.

CO.4: Fit the regression equations using the method of least squares.

CO.5: Describe data mining and data warehousing.

CO.6: Define data mining models and algorithms.

CO.7: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO 1.1 Describe Coefficient of Correlation. MO 1.2 Compute Karl Pearson's Coefficient of Correlation.	Understand Apply

	MO 1.3 Describe Rank Correlation Coefficient. MO 1.4 Compute Spearman's Rank correlation coefficient. MO 1.5 Describe Correlation Ratio.	Understand Apply Remember
Module:II	MO 2.1 Explain Association of attributes. MO 2.2 Describe the concepts of curve fitting. MO 2.3 Discuss partial and multiple regressions for three variables.	Understand Understand Remember
Module: III	MO 3.1 Explain the regression equations. MO 3.2 Derive the angle between regression lines. MO 3.3 Define standard error, probable error and coefficient of determination.	Understand Understand Remember
Module: IV	MO 4.1 Describe Data mining and data warehousing. MO 4.2 Describe OLAP. MO 4.3 Explain summarization and visualization of data mining. MO 4.4 Explain clustering and link analysis of data mining. MO 4.5 Describe predictive data mining.	Remember Remember Remember Remember Remember
Module: V	MO 5.1 Describe Neural Networks. MO 5.2 Define Decision trees. MO 5.3 Explain logistic regression. MO 5.4 Explain discriminant analysis. MO 5.5 Define Nearest neighbourhood techniques.	Remember Remember Remember Remember Remember
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Correlation- scatter diagram, Karl Pearson's coefficient of correlation and its properties, correlation ratio. Concept of rank correlation, Spearman's rank correlation coefficient, repeated ranks.

Module II Association of attributes, partial and multiple correlation for three variables (without proof). Curve fitting and principle of least squares- fitting of first degree, second degree, power curves and exponential curves.

Module III Simple regression analysis- regression equations by method of least squares, linear regression coefficients and its properties. Angle between the regression lines. Standard error, probable error, coefficient of determination.

Module IV Introduction. Data mining and data warehousing; Data mining and OLAP; Data Description for data mining (Summaries and Visualization, Clustering, Link Analysis) Predictive data mining: Types of predictions (Classification, Regressions and Time series)

Module V Networks; Decision trees; Logistic regression, Discriminant analysis, Nearest neighbourhood techniques.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References

1. Andrew S. Tanenbaum (1996). *Computer Networks*. 3rd edition, Bratislava. ISBN-10.
2. David W. Hosmer and Stanley Lemeshow (2000). *Applied Logistic Regression*. 2nd edition. Wiley series in probability and statistics, New York.
3. Eibe Frank and Mark Hall (2011). *Data mining; practical machine learning tools and techniques*. 3rd Edition. Elsevier India.
4. Gupta S. C. and Kapoor, V. K. (1984). *Fundamentals of Mathematical Statistics.* Sulthan Chand & Co. 3rd edition. New Delhi.
5. Gupta, G. K. (2011). *Introduction to Data mining with case studies*. PHI. New Delhi.
6. Michael J. Craley (2013*). The R Book*, second edition, Wiley, New York.
7. Purohit, S. G., Deshmukh, S.R., & Gore, S. D. (2008). *Statistics using R*. Alpha Science International, United Kingdom.
8. Saxena H.C. (1983). *Elementary Statistics*. S. Chand & Co., New Delhi. ISBN-9788121909259.
9. William R Klecka (1980*). Discriminant Analysis*. Sage publications, Inc., New York.

10. William Stallings (2005). *Wireless Communications*. Pearson Prentice Hall, UK.

Web Resources:

www.fgcu.edu/support/office2000
www.openoffice.org*Open Office web site*
www.microsoft.com/office*MS Office web site*
www.lgts.org*Office on-line lessons*
www.learnthenet.com*Web Primer*
www.computer.org/history/timeline
www.computerhistory.org
http://computer.howstuffworks.com
www.keralaitmission.org
www.technopark.org
http://ezinearticles.com/?Understanding-The -Operation-Of-Mobile -Phone –Networks & id=68259

III Semester- Core Course 3

ST 1341: Probability and Distributions – I

Hours/Week: 5

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Describe random experiment, sample space, events, types of events.

CO.2: Describe various definitions of probability, conditional Probability and multiplication theorem, and their applications in problem solving

CO.3: Learn the concept of geometric probability

CO.4: Describe univariate random variables in Discrete as well as in continuous cases, distribution function, probability mass function and probability density function, apply their properties in problem solving

CO.5: Describe bivariate random variable, joint distribution function, joint probability mass function, marginal and conditional distributions, independence of random variables and apply their properties in problem solving

CO.6: Describe functions of random variables both in univariate and bivariate cases, transformations of random variable and apply the concepts in problem solving

CO.7: Describe mathematical expectation, expectation of function of random variables (up to bivariate case) and apply its properties in problem solving

CO.8: Apply the concepts of correlation coefficient, conditional expectation (regression function), and conditional variance in problem solving

CO.9: Learn various generating functions and their properties

CO.10: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:		**Taxonomy Level**
Module: I	MO 1.1	Describe random experiment, sample space, events, types of Events	Understand
	MO 1.2	Define mathematical, statistical and axiomatic definitions of Probability	Understand
	MO 1.3	Describe probability space, elementary properties of probability, Addition theorem	Apply
	MO 1.4	Demonstrate conditional probability, multiplication theorem	Understand
	MO 1.5	Demonstrate Bayes theorem and its applications	Apply
	MO 1.6	Describe concept of geometric probability	Understand
Module: II	MO 2.1	Describe univariate random variables in discrete and continuous cases	Understand
	MO 2.2	Describe distribution function of a random variable and its properties	Understand
	MO 2.3	Demonstrate probability mass function, probability density function and their properties	Understand
	MO 2.4	Demonstrate functions of random variable, transformation of random variable (univariate)	Understand
Module: III	MO 3.1	Describe bivariate random variable	Understand
	MO 3.2	Describe joint distribution function and its properties (bivariate case)	Understand
	MO 3.3	Demonstrate joint probability mass function and joint	Understand

		probability density function and their properties (bivariate case)	
	MO 3.4	Demonstrate marginal and conditional distributions (bivariate case)	Apply
	MO 3.5	Demonstrate independence of random variables (bivariate case)	Apply
	MO 3.6	Demonstrate Jacobian of transformations (bivariate case)	Understand
Module: IV	MO 4.1	Demonstrate Mathematical expectation and its properties	Apply
	MO 4.2	Demonstrate expectation of function of bivariate random variables	Understand
	MO 4.3	Describe moments of univariate and bivariate random variables	Apply
	MO 4.4	Describe Cauchy – Schwartz inequality	Understand
	MO 4.5	Calculate correlation coefficient of random variables	Apply
	MO 4.6	Describe conditional expectation (regression function)	Apply
	MO 4.7	Describe examples of random variables whose expectation do not exist	Remember
Module: V	MO 5.1	Describe generating functions– probability generating function, moment generating function, characteristic function, cumulant generating function, their properties	Apply
	MO 5.2	Demonstrate the derivation of moments from generating functions	Understand
	MO 5.3	Describe bivariate moment generating function	Understand
	MO 5.4	Describe examples of random variables whose moment generating function do not exist	Remember
Module: VI (for practical exam only)	MO 6.1	Use R built in functions to solve numerical problems associated with topics coveredin various modules	Apply

COURSE CONTENT

Module I Random Experiment, Sample Space, Events, Types of Events, Mathematical and Statistical definitions of Probability, Axiomatic definition, Probability space, Elementary

properties of probability, Addition theorem, Conditional Probability, Multiplication theorem, Concept of geometric probability, Bayes theorem and its applications.

Module II Random variable, Distribution function of a random variable, Its properties, Discrete and Continuous type random variables, probability mass function and probability density function, their properties, functions of random variables, transformation of random variables.

Module III Bivariate random variable, joint distribution function and its properties, joint probability mass function and joint probability density function and their properties, marginal and conditional distributions, independence of random variables, Jacobian of transformations.

Module IV Mathematical expectation examples, properties, addition and multiplication theorem on expectation, expectation of function of random variables, moments-univariate and bivariate, Cauchy – Schwartz inequality, correlation coefficient, conditional expectation (regression function), conditional variance, examples of random variables whose expectation do not exist.

Module V Generating functions– probability generating function, moment generating function, characteristic function, cumulant generating function, their properties derivation of moments from generating functions, bivariate moment generating function, examples of random variables whose moment generating function do not exist.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References:

1. Bhat, B. R., Sri. Venkata Ramana T and Rao Madhava K. S. (1977). *Statistics: A Beginners Text Vol- 2*, New Age International (P) Ltd., New Delhi.
2. F. M. Dekkingetal. (2005). *A Modern Introduction to Probability and Statistics*. Springer Verlag, New York. 9
3. Goon A. M., Gupta N.K., Das Gupta B. (1999). *Fundamentals of Statistics. Vol. 2* World Press, Kolkatta.

4. Gupta, S.C. and Kapoor, V.K. (2002). *Fundamentals of Mathematical Statistics*, Sulthan Chand, New Delhi.
5. Hogg, R.V. and Craig, A.T. (1970). *Introduction to Mathematical Statistics.* Pearson Education Pvt. Ltd, UK.
6. Mukhopadhaya, P. (1996). *Mathematical Statistics.* New Central Book Agency (P) Ltd., Calcutta.
7. Rohatgi, V. K. *An Introduction to Probability Theory and Mathematical Statistics*.Wiley eastern Limited
8. Rohatgi, V. K and Saleh, A.K.MD. (2001). *An Introduction to Probability and Statistics*. 2nd edition. John Wiley & Sons, Inc., New York.
9. Wilks, S.S. (1964). *Mathematical Statistics*, John Wiley, New York.

IV Semester- Core Course 4

ST 1441: Probability and Distributions – II

Hours/Week: 5

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Describe the univariate discrete distributions- Degenerate, Bernoulli, Binomial, Poisson, Geometric and Hyper geometric.

CO.2: Define multinomial distribution and its properties.

CO.3: Describe the univariate continuous distributions-Uniform, Triangular, Gamma, Beta 2 types, Exponential, Normal, Lognormal and Cauchy.

CO.4: Explain the concepts of multivariate normal distribution.

CO.5: Derive the marginal and conditional distribution of bivariate normal distribution.

CO.6: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**

Module: I	MO 1.1 Explain Degenerate distribution, Uniform distribution on n points and Bernoulli distribution. MO 1.2 Explain Binomial distribution and derive its Characteristics. MO 1.3 Explain Poisson distribution and derive its Characteristics. MO 1.4 Fit Binomial and Poisson Distributions. MO 1.5 Define Negative binomial distribution.	Apply Apply Apply Analyze Understand
Module: II	MO 2.1 Explain Geometric distribution and derive its characteristics. MO 2.2 Derive lack of memory property of Geometric distribution. MO 2.3 Describe multinomial distribution and derive its characteristics. MO 2.4 Define Hyper geometric distribution and derive its mean and variance.	Understand Understand Understand Understand
Module: III	MO 3.1 Explain continuous uniform distribution, triangular distribution and gamma distribution and its characteristics. MO 3.2 Describe beta distribution- two types and derive mean and variance of both types. MO 3.3 Explain exponential distribution and derive its characteristics. MO 3.4 Define double exponential distribution.	Understand Understand Understand Remember
Module: VI	MO 4.1 Explain normal distribution and derive its characteristics properties. MO 4.2 Discuss standard normal distribution and use of standard normal tables. MO 4.3 Define Lognormal distribution and derive its mean and variance. MO 4.4 Define Cauchy distribution.	Apply Understand Understand Understand
Module: V	MO 5.1 Describe multivariate normal distribution. MO 5.2 Derive mean vector and dispersion matrix multivariate normal distribution. MO 5.3 Derive the joint characteristic function of multivariate normal distribution.	Understand Understand Understand

	MO 5.4 Derive marginal and conditional distributions of bivariate normal distribution.	Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Discrete probability distributions - I: Degenerate distribution-mean, variance and mgf; Uniform distribution on *n* points-mean and variance; Bernoulli distribution – mean, variance and mgf; Binomial distribution, Poisson distribution – Poisson distribution as limiting case of binomial distribution, first four raw moments and central moments, beta and gamma coefficients, mgf and probability generating function, recurrence relations for the moments, mode, additive property, other simple distributional properties and fitting etc. of both binomial and Poisson. Negative binomial distribution – mean and variance, mgf, additive property.

Module II Geometric distribution – mean and variance, mgf and probability generating function, Lack of memory property; Multinomial distribution mgf, mean, variance and covariances; Hypergeometric distribution – mean and variance.

Module III Continuous probability distributions I - Uniform distribution-mean, variance and mgf, Probability integral transformation; Triangular distribution-mean, variance and mgf; Gamma distribution-mean and variance, mgf, additive property; Beta distribution-two types, means and variance of both types, Exponential distribution – mean, variance and mgf, Lack of memory property, application in life testing problems, double exponential distribution.

Module IV Continuous probability distributions II - Normal distribution – raw moments and central moments, beta and gamma coefficients, mgf and characteristic function, mode and median, linear combination of independent normal variates, Standard normal distribution, its chief properties and use of standard normal tables, fitting of normal distribution. Lognormal distribution – mean and variance, skewness and kurtosis properties, application in

Economics. Cauchy distribution – standard form, non-existence of mean, characteristic function (without derivation) and simple distributional properties;

Module V Basic concepts of Multivariate Normal Distribution – Introduction to p – variate random vectors, mean vector and dispersion matrix, Multivariate normal distribution – pdf, joint characteristic function, distributions of the components of multivariate normal random vector through characteristic function, bivariate normal distribution as a special case of multivariate normal, marginal and conditional distributions of bivariate normal distribution (with derivation)

Module VI Practical based on Modules I to V.Practical is to be done using R package.

References:

1. Bhat, B. R., Sri. Venkata Ramana, T. and Rao Madhava, K.S. (1977). *Statistics: A Beginners Text* Vol- 2, New Age International (P) Ltd., New Delhi.
2. Dekking, F. M. (2005). *A Modern Introduction to Probability and Statistics: Understanding Why and How.* Springer Science & Business Media, New York.
3. Goon, A. M., Gupta, N.K., Das Gupta, B. (1999). *Fundamentals of Statistics*- Vol.2. World Press, Kolkatta.
4. Gupta, S.C. and Kapoor, V.K. (2002). *Fundamentals of Mathematical Statistics*. Sulthan Chand, New Delhi.
5. Hogg, R.V. and Craig, A.T. (1970). Introduction *to Mathematical Statistics*, Pearson Education. Pvt. Ltd. UK.
6. Mukhopadhaya, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd., Calcutta.
7. Rohatgi, V.K. and Saleh, A.M.E. (2001). *An Introduction to Probability and Statistics*. 2 nd edition. John Wiley & Sons, Inc, New York.
8. Rohatgi, V. K. *An Introduction to Probability Theory and Mathematical Statistics*. Wileyeastern Limited.
9. Wilks S.S. (1964). *Mathematical Statistics*, John Wiley, New York.

IV Semester- Core Course 5

ST 1442: Practical I

Numerical problems based on Core Courses ST 1141: Statistical Methods I, ST 1241: Statistical Methods II, ST 1341: Probability and Distributions-I and ST 1441: Probability and Distributions - II

Record of Practical

Presenting the certified record is mandatory to appear for the practical examination.Questions are to be worked out in each sheet based on the topics in the syllabus as follows:

Sheet	Title
1	Diagrams and Graphs
2	Measures of Central Tendency
3	Measures of Dispersion
4	Moments, Skewness and Kurtosis
5	Correlation
6	Regression Analysis
7	Fitting of Curves
8	Probability
9	Discrete Probability Distributions
10	Continuous Probability Distributions

V Semester- Core Course 6

ST 1541: Limit Theorems and Sampling Distributions

Hours/Week: 5

Course Outcomes

On completion of the course, the students should be able to

CO.1: Understand the convergence of a sequence of events.

CO.2: Explain the laws of large numbers.

CO.3: Apply Chebychev's inequality and central limit theorem.

CO.4: Describe central and non-central sampling distributions.

CO.5: Make use of tables of χ^2, t and F distributions.

CO.6: Explain the probability distributions of r^{th} order statistic.

CO.7: Explain probability distributions of 1^{st} and n^{th} order statistic from U (0, θ) and exponential distributions.

CO.8: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO 1.1 Define limit of a sequence of real numbers	Remember
	MO 1.2 Explain limit infimum and limit supremum of a sequence of events	Understand
	MO 1.3 Explain monotone and continuity property of probability measure	Understand
	MO 1.4 Explain Borel-Cantelli lemma	Understand
Module: II	MO 2.1 Describe convergence in probability and convergence in law	Understand
	MO 2.2 Explain Bernoulli law of large numbers, Chebychev's weak law of large numbers and Lindberg-Levy form of central limit theorem	Understand
	MO 2.3 Apply Chebychev's inequality	Apply
	MO 2.4 Describe central limit theorem	Understand
Module: III	MO 3.1 Explain random sample, statistic, sampling distribution and standard error	Understand
	MO 3.2 Explain the sampling distribution of mean and variance of samples arising from normal distribution	Understand
	MO 3.3 Make use of mgf of χ^2 distribution	Apply
	MO 3.4 Make use of $\chi 2$ tables	Apply
Module: IV	MO 4.1 Explain central and non-central t and F distributions	Understand
	MO 4.2 Explain the inter relationships between χ^2, t, F and standard normal distributions	Understand

	MO 4.3 Make use of t and F tables	Apply
Module: V	MO 5.1 Explain order statistic and empirical distribution function MO 5.2 Explain probability distribution and moments of r^{th} order statistic MO 5.3 Explain the probability distribution of 1^{st} and n^{th} order statistic from U(0,θ) and exponential distributions	Understand Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Introduction to measure theoretic probability: Sequence of events, limit of events – limit supremum, limit infimum, monotone and continuity property of probability measure, independence of finite number and sequence of events, Borel- Cantelli lemma.

Module II Chebychev's inequality, convergence in probability, convergence in law, Bernoulli Law of large numbers, Chebychev's weak law of large numbers, concept of central limit theorem, Lindberg-Levy Central Limit theorem, application of central limit theorem.

Module III Sampling distributions: Concept of random sample and statistic, definition of sampling distribution, standard error; sampling distribution of the mean and variance of a sample arising from a normal distribution; χ^2 distribution-mean and variance, mgf, additive property and use of χ^2 tables. Non-central χ^2 distribution (definition only)

Module IV Student's t distribution- mean and variance; use of t tables; Definition of non–central t distribution, F-distribution – mean and variance, use of F tables, definition of F distribution; inter-relationships between the standard normal, χ^2, t and F distributions.

Module V Introduction to order statistics: Empirical distribution function, order statistic, probability distribution of r^{th} order statistic, moments of r^{th} order statistic, probability distribution of 1^{st} and n^{th} order statistics from U(0, θ) distribution and exponential distribution.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References:

1. Bhat, B. R. (2007*). Modern Probability Theory - An Introductory Text Book,* New Age International Publishers, New Delhi.
2. Gupta, S.C. and Kapoor, V.K. (2002). *Fundamentals of Mathematical Statistics,* Amerind Publishing Co. Pvt. Ltd., New Delhi.
3. Rohatgi, V.K. and Saleh A.M.E. (2001). *An Introduction to Probability and Statistics*. 2nd edition, John Wiley and Sons Inc., New York.
4. Rohatgi, V. K. (1976). *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd.

V Semester- Core Course 7

ST 1542: Estimation

Hours/Week: 5

Course Outcomes

On completion of the course, the students should be able to

CO.1: Define the desirable properties of a good estimator.

CO.2: Explain whether an estimator satisfy any of the desirable properties or not.

CO.3: Construct confidence intervals for mean, variance, proportion in a population and difference between means and difference between proportions in two populations.

CO.4: Explain Gauss Markov set up.

CO.5: Illustrate the estimability of a linear parametric function.

CO.6: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcome

Sl. No.	Outcomes On completion of each module students will be able to:	Taxonomy Level
Module: I	MO 1.1 Define parameter and parameter space MO 1.2 Explain the difference between estimate and estimator MO 1.3Illustrate whether an estimator is unbiased or	Remember Understand Understand

	not MO 1.4 Illustrate whether an estimator is consistent or not	 Understand
Module: II	MO 2.1 Explain sufficiency of a statistic MO 2.2 Explain efficiency of an estimator MO 2.3 Make use of Fisher-Neyman Factorization theorem to identify sufficient statistic MO 2.4 Make use of Cramer-Rao inequality to calculate the minimum variance that can be achieved by any unbiased estimator MO 2.5 Examine the existence of minimum variance bound estimator	Understand Understand Apply Apply Apply
Module: III	MO 3.1 Explain confidence interval MO 3.2 Explain confidence coefficient MO 3.3 Construct confidence intervals for mean, variance, proportion in a population and difference between means and difference between proportions in two populations	Understand Understand Apply
Module: IV	MO 4.1Explain method of moments, method of maximum likelihood and method of least square estimation MO 4.2 Identify maximum likelihood estimator MO 4.3 Identify estimator by the method of moments MO 4.4 Identify estimator by the method of least squares	Understand Apply Apply Apply
Module: V	MO 5.1Explain Gauss Markov set up MO 5.2 Explain Gauss Markov theorem MO 5.3 Explain estimability of linear parametric functions	Understand Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Point estimation: Problem of point estimation; parameter space, estimator and estimate; Unbiasedness, Consistency, sufficient condition for consistency and its use.

Module II Sufficiency with examples, Factorization theorem (statement only) and its application; Efficiency; Minimum variance unbiased estimator, Cramer –Rao inequality (statement only) and its application; Minimum variance bound estimator.

Module III Interval estimation-Interval estimation: basic concepts-confidence interval, confidence coefficient; Constructing confidence intervals for each of the mean, variance and proportion of a population, and for each of the difference of means and the difference of proportion of two populations.

Module IV Methods of estimation: Method of moments, properties of moment estimator (statement only); Method of maximum likelihood, properties of likelihood estimator (statement only), Method of least squares.

Module V Gauss-Markov set up, Theory of linear estimation, estimability of parametric functions, Gauss – Markov theorem.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References

1. Gupta, S. C and Kapoor, V. K (2002). *Fundamentals of Mathematical Statistics,*Amerind Publishing Co. Pvt. Ltd.
2. Hogg, R. V and Craig, A. T (1970). *Introduction to Mathematical Statistics,* AmerindPublishing Co. Pvt. Ltd.
3. Joshi, D.D. (1987). *Linear Estimation and Design of Experiments.* Wiley Eastern Ltd., New Delhi
4. Mukhopadhaya. P. (1996). *Mathematical Statistics,* New Central Book Agency (P) Ltd., Calcutta.
5. Rohatgi, V.K. *An Introduction to Probability Theory and Mathematical Statistics*.

Wiley Eastern Ltd.

6. Rohatgi, V. K and Saleh, A.K.MD. (2001). *An Introduction to Probability andStatistics,* 2nd edition. John Wiley & Sons, Inc, New York.

V Semester- Core Course 8

ST 1543: Testing of Hypothesis

Hours/Week: 5

Course Outcomes

On completion of this course, the students will be able to**:**

CO.1: Describe the fundamental concepts of testing of hypothesis.

CO.2: State Neyman-Pearson lemma

CO.3: Apply Neyman Pearson's lemma for mean and variance of a normal population, the Mean of binomial and Poisson distribution

CO.4: Define most powerful test and UMP test

CO. 5: Explain likelihood ratio test and its properties.

CO. 6: Apply large sample tests and small sample tests.

CO.7: Describe non-parametric test.

CO.8: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl.No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy level**
Module:I	MO 1.1 Describe the basic concept of testing of hypothesis. MO1.2 Describe simple and composite hypothesis with example. MO 1.3 Explain the procedure of testing a Statistical hypothesis. MO1.4 Calculate two types of errors, level of significance, and power of a test	Understand Understand Understand Apply

	MO 1.5 Define critical region, power curve and power function.	Understand
Module:II	MO 2.1 State Neyman-Pearson lemma to find mostPowerful test. MO 2.2 Define most powerful test and UMP test MO 2.3 Derivation of test using Neyman Pearson's lemma for mean and variance of a normal population, the mean of binomial and Poisson distribution MO 2.4 Explain likelihood ratio test and its properties	Understand Understand Apply Understand
Module: III	MO 3.1 Carryout the test for testing proportion of a population and equality of two proportions for large samples. MO 3.2 Carryout the test for testing mean of a population and equality means of two populations for large samples. MO 3.3 Carryout the test for testing correlation coefficient and difference between two correlation coefficients. MO 3.4 Perform test based on chi– square distribution – testing the goodness of fit, testing the independence of attributes	Analyze Analyze Analyze Analyze
Module: IV	MO 4.1 Carryout the test based on student's 't' distribution– test of significance of mean from a normal population. MO 4.2 Carryout the test for testing the equality of means of two normal population MO 4.3 Carryout the Paired't' test. MO 4.4 Carryout the test based on F distribution– testing the equality of variances of two normal populations.	Analyze Analyze Analyze Analyze
Module: V	MO 5.1 Define Non-parametric estimation, estimable parameter, Kernal-U-statistic, empirical distribution function MO 5.2 Explain Kolmogorov Smirnov one sample and two sample tests MO 5.3 Explain Sign test for one sample and two samples MO 5.4: Describe Run test MO 5.5: Explain Wilcoxon signed rank test.	Remember Understand Understand Understand Understand

	MO 5.6: Describe Median test MO 5.7: Describe Mann-Whitney-Wilcoxon test.	Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Statistical hypothesis– simple and composite, null and alternative hypothesis, test of hypothesis, two types of errors, level of significance, size and power of a test, critical region, power curve and power function.

Module II Neymann– Pearson's approach of test of hypothesis, Neymann– Pearson's lemma (Without proof), most powerful test, uniformly most powerful test, derivation of test using Neyman Pearson's lemma for mean and variance of a normal population, the mean of binomial and Poisson distribution, likelihood ratio test and its properties (statement only)

Module III Test of significance – Large sample tests-testing the significance of a proportion, testing the equality of two proportions, testing the significance of a mean, testing the equality of two means, testing the significance of correlation coefficient, testing the significance of difference between two correlation coefficients. Tests based on chi– square distribution – testing the goodness of fit, testing the independence of attributes, testing the significance of standard deviation of a normal population.

Module IV Small sample tests: test based on student't' distribution– test of significance of mean from a normal population, testing the equality of means of two normal population, testing the significance of correlation coefficient, paired 't' test. Test based on F distribution– testing the equality of variances of two normal populations.

Module V Non-parametric estimation-estimable parameter-degree of an estimable parameter-Kernal-U-statistic-empirical distribution function-Kolmogrov-Sminorv statistic, Kolmogorov Smirnov one sample and two sample tests-sign test for one sample and two samples-run test-Wilcoxon signed rank test. Two sample problems-median test-Mann-Whitney-Wilcoxon test

Module VI Practical based on Modules I to V. Practical is to be done using R package.

Reference Books

1. Goon, A.M, Gupta, M.K and Das Gupta (1994). *An outline of statistical theoryVol-I*, World Press Calcutta.
2. Gupta, S.C and Kapoor, V.K (2002). *Fundamentals of Mathematical Statistics*, Sultan Chands.
3. Hogg, R.V., Craig, A.J. (2011). *Introduction to Mathematical Statistics*, 4thedition, Collier McMillan.
4. Mood, A.M, Graybill, F.A. and Bose, D.P. (1972). *Introduction to theory of statistics*, 3rdedition–Mc Graw Hill.
5. Rohatgi, V.K. (1984). *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern, New York.
6. Rohatgi, V.K and Saleh, A.K. MD. (2001). *An Introduction to Probability and Statistics*, 2ndedition. John Wiley & Sons, Inc., New York.
7. Wilks, S.S(1962). *Mathematical Statistics*, John Wiley, New York.

V Semester- Core Course 9

ST 1544: Sample Survey Methods

Hours/Week: 5

Course Outcomes

On completion of this course, the students will be able to**:**

CO.1: Explain the basic concept of sample survey.

CO.2: Distinguish between sample survey and census survey

CO.3: Apply various sampling schemes like SRS, Stratified sampling and Systematic sampling

CO.4: Compare the efficiencies of estimates obtained using different sampling techniques.

CO.5: Describe the merits and demerits of different sampling techniques.

CO.6: Obtain the estimates for population mean using Ratio and Regression estimators, and compare their efficiencies

CO.7: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No.	**Outcomes** On completion of each module, students should be able to:	**Taxonomy level**
Module: I	MO 1.1 Explain the basic concepts of sampling. MO 1.2Discuss the advantages and disadvantages of sampling over census. MO 1.3 Distinguish between probability and non- probability sampling, sampling and non- sampling errors. MO 1.4 Explain the organizational aspects of sample survey	Understand Understand Understand Understand
Module: II	MO 2.1 Distinguish between simple random sampling with and without replacement. MO 2.2 Evaluate the estimates of population mean and total for variables, variance of the estimates, and the confidence interval containing population mean MO 2.3 Find the estimates for population proportion, of SRS for attributes MO 2.4 Explain determination of sample size based on desired accuracy, for variables and attributes	Apply Apply Understand Apply

Module: III	MO 3.1 Draw a stratified sample MO 3.2 Obtain the estimates for population mean, assuming SRSWOR within the strata MO 3.3 Explain allocation of sample size in different strata, using proportional allocation and optimum allocation with and without varying cost	Apply Understand Apply
Module: IV	MO 4.1 Draw a systematic sample; linear and circular systematic samples MO 4.2 Obtain the estimates for population mean under systematic sampling MO 4.3 Compare the efficiencies of estimates of population mean of systematic random sampling with respect to SRS and stratified random sampling. MO 4.4 Compare the estimates of population mean, for a population with linear trend.	Apply Understand Understand Understand
Module: V	MO 5.1 Explain ratio and regression estimators forpopulation mean. MO 5.2 Discuss the bias and approximate variance of ratio estimators MO 5.3 Compare the efficiencies of ratio and regression estimates with mean per unit.	Understand Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT:

Module I Concepts of population and sample, sampling frame, sampling design, need for sampling, principle steps in sample survey, advantages of sample survey over census survey, probability sampling and non-probability sampling, basic concepts in sampling, organisational aspects of survey sampling, sampling and non – sampling errors, sample selection and sample size.

Module II Simple random sampling with and without replacement, estimation of population mean and variance, expectation and variance of estimators, unbiased estimators of variances of these estimators confidence interval for population mean, SRS for attributes, estimation of sample size based on desired accuracy for variables and attributes.

Module III Stratified sampling: Concepts of stratified population, and stratified sample estimation of population mean and total, mean and variance of estimator of population mean assuming SRSWOR with in strata, proportional allocation, Optimum allocation with and without varying costs, comparison of simple random sampling with proportional and optimum allocation.

Module IV Systematic sampling: Concepts of systematic population, systematic sample, estimation of population mean and total, expectation and variance of estimators, circular systematic sampling, comparison with stratified sampling, population with linear trend.

Module V Ratio and regression estimators under SRSWOR, ratio estimators for population mean and variance, expectation– bias – approximate variance, estimator for variance, Regression estimates of population mean and total.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References

1. Cochran, W.G. (1977). *Sampling Techniques*. Wiley Eastern Ltd., New Delhi.
2. Gupta, S.C. and Kapoor, V.K. (2002). *Fundamentals of Applied Statistics*, Sultan Chand & Co. New Delhi.
3. ParimalMukhopadyay. (2009). *Theory and Methods of Survey Sampling*. PHI Learning Pvt Ltd. New Delhi.
4. Sambath. (2001). *Sampling Theory and Methods*. Narosa Publishing House. New Delhi, Chennai, Mumbai, Calcutta.
5. Murthy, M.N. (1967). *Sampling theory and Methods*. Statistical Publishing Society, Calcutta.
6. Sukhatme, P.V. and Sukhatme, B.V. (1970). *Sampling Theory of Surveys with Applications*. Indian Society of Agricultural Statistics.

VI Semester: Core Course 10

ST 1641: Design of Experiments and Vital Statistics

Hours/Week: 7

Course Outcomes

On completion of this course, the students will be able to**:**

CO.1: Carry out one-way and two-way analysis of variances.

CO.2: Explain the basic concepts and principles of experimental design.

CO.3: Carry out the analysis of CRD, RBD and LSD.

CO.4: Carry out analysis in RBD and LSD with one or two missing observations.

CO.5: Carry out the analysis of 2^2 and 2^3 factorial experiments.

CO.6: Compute various measures of fertility, mortality and population growth.

CO.7: Construct life tables.

CO.8: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No.	**Outcomes** On completion of each module, students should be able to:	**Taxonomy level**
Module: I	MO 1.1 Explain the basic concepts and principles of experimental design	Understand
	MO 1.2 Carry outone way and two way ANOVA	Apply
Module: II	MO 2.1 Compare CRD, RBD and LSD.	Analyze
	MO 2.2 Carry out RBD and LSD designs with one or two missing observations.	Analyze
	MO 2.3 Explain the efficiencies of RBD over CRD, LSD over RBD and LSD over CRD	Understand

Module: III	MO 3.1 Explain basic concepts of 2^n factorial experiments MO 3.2 Carry out the analysis 2^2 and 2^3 factorial experiments MO 3.3 Describe the Yates's method of computing factorial effect totals MO 3.4 Explain confounding in factorial designs	Understand Apply Analyze Understand
Module: IV	MO 4.1 Discuss the sources of collecting data on vital statistics MO 4.2 Compute various measurements of Mortality MO 4.3 Construct life tables MO 4.4 Explain the concepts of central mortality and force of mortality.	Understand Apply Analyze Remember
Module: V	MO 5.1 Compute the measure(s) of fertility rate for a given data. MO 5.2 Calculate various measures of population growth. MO 5.3 Explain the concepts of stationary and stable population	Apply Apply Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT:

Module I Analysis of variance for one way and two-way classification layout and analysis, principles of experimentation - randomisation, replication and local control.

Module II Basic designs: CRD, RBD (one observation per cell), LSD layout and analysis, missing plot technique for one or two missing observations, efficiency of RBD over CRD, LSD over RBD and LSD over CRD.

Module III Factorial Experiments: Basic concepts of 2^n factorial experiments, main effects and interaction, confounding, Yates method of analysis.

Module IV Demography, sources of collecting data on vital statistics-census, registration, adhoc surveys, hospital records, life tables, measurement of mortality, crude death rate, age specific death rate, infant mortality rate, standardized death rate, complete life table, its main features, mortality rate and probability of dying.

Module V Measurement of fertility, crude birth rate, general fertility rate, age specific birth rate, total fertility rate, gross reproduction rate and net reproduction rate.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References

1. Benjamin, B (1960). *Elements of Vital Statistics*. G. Allen & Unwin.
2. S. C. Gupta and V. K. Kapoor (2002)- *Fundamentals of Applied Statistics*. Sultan Chand & Co. New Delhi.
3. ParimalMukhopadyay. (2005). *Applied Statistics*. Arunabha Sen Books and Allied Ltd. Kolkata.
4. Cochran, W.G and Cox, G.M. (1992). *Experimental Designs*. John Wiley, New York.
5. Das, M.N. and Giri, N. C. (1979). *Design and Analysis of Experiments*. Wiley-Eastern Ltd., New Delhi.
6. Joshi, D. D. (1987). *Linear Estimation and Design of Experiment*. Wiley-Eastern Ltd., New Delhi.
7. Kemthorne, O. (2005) *Design and Analysis of Experiments*. Wiley, New York.
8. Srivastva, O. S (1983). *A Text Book of Demography*. Stosius Inc/Advent Books Division

VI Semester: Core Course 11

ST 1642: Applied Statistics

Hours/Week:6

Course Outcomes

On completion of the course, students should be able to:

CO.1: Identify the various index numbers and compute them for data sets.

CO.2: Explain the concepts of base shifting, splicing and deflation of index numbers, consumer price index number.

CO.3:Explain the component of time series and estimate trend and seasonal effect.

CO.4:Explain the roles and responsibilities of various organizations.

CO.5:Explain the methods of data collection and dissemination in population census.

CO.6: Explain the methods of estimation of National Income.

CO.7: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO1.1: Explain of index numbers and its applications MO1.2: Explain the various methods of constructing price and quantity index numbers. MO1.3: Distinguish between various index numbers and compute their values.	Understand Apply Evaluate
Module: II	MO 2.1 Carryout various tests on index numbers. MO 2.2 Explain the concept of base shifting, splicing, and deflating. MO 2.3 Construct consumer price index number MO 2.4 Explain bias of Index numbers.	Evaluate Understand Apply Understand
Module: III	MO 3.1 Explain the concept of time series. MO 3.2 Explain the concept of components of time series. MO 3.3 Explain the concepts of additive and multiplicative models. MO 3.4 Estimation and elimination of the trend using graphical, semi -average, moving average and least square method.	Remember Understand Understand Analyze

Module: IV	MO 4.1 Explain the need for study of seasonal variation. MO 4.2 Estimation and elimination of seasonal variation using method of simple averages- ratio to trend method, ratio to moving average method, method of link relatives MO 4.3 Discuss the merits and demerits of above methods.	Understand Apply Understand
Module: V	MO 5.1 Explain the roles and responsibilities of NSO, MOSPI MO 5.2 Explain various concepts associated with Population Census. MO 5.3 Describe De-Facto and De-Jure methods of population census. MO 5.4 Explain different domains of official statistics MO 5.5 Explain methods of National Income Estimation	Understand Understand Understand Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT:

Module I Index Numbers: meaning-classification-construction of index numbers-un weighted index numbers-weighted index numbers-Laspeyre's, Paasche's, Dorbish-Bowley's, Fisher's, Marshall-Edgeworth's and Kelly's Methods-Quantity index numbers.

Module II Test on index numbers-factor reversal test, time reversal test, circular test, chain Index numbers-base shifting, splicing and deflating of index numbers. Consumer price index number.

Module III Time Series: concepts of time series, components of time series-additive and multiplicative models, estimation of components-measurement of trend using graphical,

semi-average and moving average methods, method of least squares.

Module IV Measurement of seasonal variation using method of simple averages- ratio to trend method, ratio to moving average method, method of link relatives.

Module V Indian official statistics: National Statistical Office (NSO), MOSPI –population census- De Facto and De Jure method-economic census- agricultural statistics-world agricultural census-live stock and poultry statistics, forest statistics, fisheries statistics, mining and quarrying statistics, labour statistics, national income statistics, methods of national income estimation, financial statistics.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References:

1. Agarwal, B.L. (1988). *Basic Statistics*. Wiley Eastern Ltd. New Delhi.
2. Gupta, S.C. and Kapoor, V.K. (2002). *Fundamentals of Mathematical Statistics.* Sultan Chand & Sons, New Delhi.
3. Gupta, S. P (2011). *Statistical Methods.* Sultan Chand & Sons, New Delhi.
4. Kapur, J. N and Saxena, H. C. (1970). *Mathematical Statistics.* Sultan Chand & Sons, New Delhi.

VI Semester: Core Course 12

ST 1643: Operations Research and Statistical Quality Control

Hours/Week:6

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Explain the evolution and significance of OR

CO.2: Describe the concept of OR

CO.3: Solve LPP using graphical method and simplex method

CO.4: Solve LPP using Big M method and Two-phase method

CO.5: Explain the concept of SQC and mention its application

CO.6: Construct control chart for variables and attributes

CO.7: Describe acceptance sampling plans

CO.8: Practicals:

Use R built in functions to solve numerical problems associated with topics covered in various modules

Module Outcomes

Sl.No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module: I	MO1.1 Explain the evolution and significance of OR MO 1.2 Formulate LPP MO 1.3 Solve LPP using Graphical method and Simplex method	Understand Create Apply
Module: II	MO 2.1Explain the technique of Artificial variable MO 2.2 Solve LPP using Big-M method and Two-phase method MO 2.3 Explain the primal dual relationship MO 2.4 Solve transportation problem MO 2.5 Solve Assignment problem	Understand Apply Understand Apply Apply
Module: III	MO 3.1 Describe SQC and its uses MO 3.2 Explain Control charts for variables MO 3.3 Construct $\bar{x}$ chart and R chart	Understand Understand Create
Module: IV	MO 4.1 Explain control chart for attributes MO 4.2 Construct p chart, np chart, MO 4.3 Construct c chart and u chart	Understand Create Create
Module: V	MO 5.1Describe Acceptance sampling plans MO 5.2 Explain producers risk and consumer's risk MO 5.3Describe the concept of Single sampling plans MO 5.4 Describe the concept of double sampling plans MO 5.5 Explain OC Curve for Single and Double Sampling	Understand Understand Understand Understand Understand
Module: VI (for practical exam only)	MO 6.1 Use R built in functions to solve numerical problems associated with topics covered in various modules	Apply

COURSE CONTENT

Module I Introduction to Operations Research (OR)-Linear programming problem (LPP)-formulation- solving the LPP by graphical method, basic solution, optimum solution, solving the LPP by simplex method-various cases-unbounded solution, infeasible solution, alternative optimum.

Module II Need for artificial variables, two phase method, Big-M method, primal, dual-relationship, transportation problem, assignment problem.

Module III Statistical quality control (SQC), definition of quality, quality control and statistical quality control, need for SQC techniques in industry-causes of quality variation. Control chart-uses of control chart, specification and tolerance limits- 3sigma limits, warning limits. Control charts for variables- X chart and R chart-purpose of the charts-basis of subgrouping-plotting X and R results,determining the trial control limits, interpretation of control charts. Criterion for detecting lack of control in X bar and R Chart

Module IV Control chart for attributes, purpose of the chart - p chart-np chart, construction of p and np charts; Construction of c-chart and u-chart.

Module V Acceptance sampling plans for attributes, producer's risk and consumer's risk. Concepts of AQL, LTPD, AOQ, AOQL, ATI and ASN- single and double sampling plans-OC curves for single and double sampling plans.

Module VI Practical based on Modules I to V. Practical is to be done using R package.

References

1. Ekambaram, S. K. (1963). *Statistical basis of Acceptance Sampling*. Asia Publishing House.
2. Gupta, R. C. (1974). *Statistical Quality Control*. Khanna Publishers, Delhi.
3. Frederick, S. Hiller and Gerald, J. Lieberman. (1987). *Operations Research*. CBS Publishers &Distributors, Delhi.
4. Kanti Swarup, Gupta, P. K and Manmohan. (1993). *Operations Research*. Sultan Chand Publishers, New Delhi.
5. Goel and Mittal (1982). *Operations Research*. Pragathi Prakashan, Meerut.

6. Kapoor, V. K and Gupta, S. P. (1978). *Fundamentals of Applied Statistics*. Sultan Chand & Sons, New Delhi.
7. Grant, E.L. and Laven Worth, R.S. (1996). *Statistical Quality Control*. McGraw Hill.
8. Schaum's outline series (1997): Operation Research.
9. Bronson, R. and Naadimuthu, G. (1997). *Schaum's Outline of Operations Research*. McGraw Hill Professional, US.
10. Gupta, R.K. (1985). *Operations Research*. Krishna Prakashan, Mandir Meerut.
11. Hamdy, A. Taha. (1996). *Operation Research*, 6th Ed. Prentice Hall of India, New Delhi.
12. Montgomery, D.C. (1983). *Introduction to Statistical Quality Control*. John Wiley & Sons.
13. Sharma, J.K. (2001). *Operations Research-Theory and Applications*. Macmillan India Ltd.

VI Semester: Core Course 13

ST 1644: Practical II

Numerical problems based on core courses ST 1542: Estimation, ST 1543: Testing of hypothesis and ST 1544: Sample survey methods.

Record of Practical

Presenting the certified record is mandatory to appear for the practical examination.Questions are to be worked out in each sheet based on the topics in the syllabus as follows:

Sheet	Title
1	Theory of Point Estimation
2	Theory of Interval Estimation
3	Testing of Hypothesis
4	Large Sample Tests
5	Small Sample Tests
6	Non-Parametric Tests
7	Simple Random Sampling
8	Stratified Sampling
9	Systematic Sampling
10	Ratio and Regression Estimators

VI Semester: Core Course 14

ST 1645: Practical III

Numerical problems based on core courses ST 1641: Design of Experiments and Vital Statistics, ST 1642: Applied Statistics and ST 1643: Operations Research and Statistical Quality Control.

Record of Practical

Presenting the certified record is mandatory to appear for the practical examination. Questions are to be worked out in each sheet based on the topics in the syllabus as follows:

Sheet	Title
1	Linear Estimation and Analysis of Variance
2	Design of Experiments
3	Analysis of Missing Plots
4	Vital Statistics
5	Index Numbers
6	Test on Index Numbers
7	Time Series
8	Simplex Method
9	Principle of Duality
10	Statistical Quality Control

VI Semester

ST 1646: Project / Internship

VI Semester: Open Course 2

ST 1661: Elective Course

One elective to be selected by the College from among the following elective courses, which are prepared in accordance with policy of introduction of industry-based courses at the undergraduate level.

ST 1661.1: Biostatistics

ST 1661.2**:** Econometric Methods

ST 1661.3: Inventory Control and Queuing Theory

ST 1661.4: Reliability and Survival Analysis

ST 1661.5: Machine Learning

ST1661.1: Biostatistics

Hours/Week:3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Explain the basic idea of clinical trial experiments

CO2: Articulate the ethics, principles and conduct of clinical trial experiments with an overall view of Phase I-IV trials.

CO.3: Describe different studies in clinical trials.

CO.4: Demonstrate basic understanding of epidemiologic methods and study design.

CO.5: Design and analysis of epidemiological studies including case-control and cohort study designs.

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module: I	MO 1.1 Describe basic concepts of Clinical trials MO 1.2 Explain main features of the study protocol such as selection of patients, treatment schedule, evaluation of patient response. MO 1.3 Formulate objectives and end points of clinical trials	Understand Apply Create
Module: II	MO 2.1 Explain basic study designs in clinical trials MO 2.2 Define Randomized control study, Nonrandomized concurrent control study, Single center and Multi-center trials, MO 2.3 Conduct Unblinded, Single blind and Double-blind trials.	Understand Apply Analysis

Module: III	MO 3.1 Construct clinical life table in epidemiologic studies MO 3.2 Construct a Kaplan-Meier estimate of the survival function MO 3.3 Choose an appropriate method for comparing proportions between two groups MO 3.4 Interpret relative risks and odds ratios when comparing two populations	Understand Apply Evaluate Evaluate
Module: IV	MO 4.1 Describe exposure and outcome of disease MO 4.2 Recognize and describe the elements in the design of clinical trials MO 4.3 Conduct a randomized clinical trial, a cohort study, a case-control study, and a cross-sectional study.	Understand Apply Create

COURSE CONTENT

Module I Basic concepts of Clinical trial: Introduction to Clinical Trials, Main features of the study protocol- Selection of patients, treatment schedule, evaluation of patient response, Informed consent, objectives and end points of clinical trials. GCP/ICH guidelines, Overview of phase I-IV trials.

Module II Basic study designs: Randomized control study, Nonrandomized concurrent control study, Single center and Multi-center trials, Blinding and Placebos: Unblinded, Single blind and Double-blind trials, conduct of double-blind trials.

Module III Basic concepts, survival function, hazard function, censoring. Single sample methods. Life tables. Kaplan-Meier survival curve. Parametric models. Two sample methods, log-rank test, parametric comparisons. Cox's proportional hazard model, competing risks, crossover trials and further aspects.

Module IV Basics of Epidemiology: Introduction to Epidemiology, Definition, scope, and uses of epidemiology; Exposure and outcome - Measures of exposure, types of exposures, sources of exposures, Classification of diseases. Measures of disease frequency: Prevalence, Incidence, Risk, Odds of disease, Incidence time, Incidence rate. Overview of study designs: Type of study design: case-control studies, cross-sectional studies, cohort study.

References

1. Clinical Trials (2006): *A practical guide to design, analysis and reporting*. Wang D, Bakhai A. Remedica; 1st edition
2. Shein-Chung Chow and Jen-Pei Liu (2004). Design *and Analysis of Clinical Trials*: *Concepts and Methodologies* (2nd edition) Wiley-Interscience
3. Gordis Leon.(2013). *Epidemiology* (Fifth edition), Elsevier Saunders,
4. Beaglehole. R. Bonita, et. al. (2006) *Basic Epidemiology*, 2nd Edition, WHO Publication, Geneva.
5. Penny Web, Chiris Bain & Sandi Pirozzo (2005). *Essential Epidemiology-An introduction for students & Health Professionals*, Cambridge University Press.
6. Isabel dos Santos Silva, (1999) *Cancer Epidemiology*: *Principles and Methods*, International Agency for Research on Cancer.
7. Gupta, S. C and Kapoor, V. K. (1983). *Fundamentals of Statistics*. Sultan Chand and Sons, New Delhi.
8. Mathews, J. N. S. (2000). *An Introduction to Randomized Controlled Clinical Trials*. Hodder Arnold.
9. Pocock, S. J. (1983). *Clinical trials. A Practical Approach*. Wiley, New York.
10. Rohatgi, V. K. (1984). *An Introduction to Probability Theory and Mathematical Statistics*.Wiley Eastern, New Delhi.
11. Altman, D. G. (1999). *Practical Statistics for Medical Research*. Chapman &Hall.

ST 1661.2: Econometric Methods

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Explain the concept of Econometrics

CO.2: Explain simple linear regression model

CO.3: Apply the concept of ordinary least squares and estimate the parameters involved in a simple linear model

CO.4: Define a general linear model

CO.5: Recognize and discuss the problems of multicollinearity, autocorrelation and heteroscedasticity in linear regression models

CO.6: Define the concept of generalized least squares

Module Outcomes

Sl.No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy level**
Module: I	MO 1.1 Explain the concept of econometrics	Understand
	MO 1.2 Recall important economic models and identify the types of variables involved	Remember
	MO 1.3 Describe the method of ordinary least squares	Apply
	MO 1.4 List the assumptions underlying the method of least squares	Remember
	MO 1.5 Describe the properties of least square estimators	Remember
Module: II	MO 2.1 Explain simple linear regression model	Understand
	MO 2.2 Estimate the parameters in a simple linear regression model using ordinary least squares	Apply
	MO 2.4 Outline the properties of the estimators	Remember
	MO 2.5 Describe Gauss-Markov theorem	Understand
Module: III	MO 3.1 Define a general linear model and list the assumptions involved	Remember
	MO 3.2 Outline the concept of generalized least square estimators	Remember
	MO 3.3 Discuss the nature and consequences of multicollinearity in linear models	Understand
	MO 3.4 Outline some procedures to detect multicollinearity and list some remedial measures	Remember
	MO 3.5 Discuss the nature and consequences of	Understand

	autocorrelation in linear regression models MO 3.6 Outline some procedures to detect autocorrelation and list some remedial measures	 Remember
Module: IV	MO 4.1 Discuss the nature and consequences of heteroscedasticity in linear regression models MO 4.2 Outline some procedures to detect heteroscedasticity and list some remedial measures MO 4.3 Define the concept of dummy variables MO 4.4 Define the concept of lagged variables	Understand Remember Remember Remember

COURSE CONTENT

Module I Basic concepts, definition and scope of econometrics-Economic theory and mathematical economics, economic models, examples, types of variables.
Method of ordinary least squares-Assumptions underlying the method of least squares, Properties of least squares estimators

Module II Simple linear regression model, estimation of parameters- ordinary least square method, properties of estimators, Gauss-Markov theorem.

Module III General linear model-assumptions, least square estimators.Generalized least square estimators, Multicollinearity- nature, consequences, detection and remedial measures. Auto correlation- nature, consequences, detection and remedial measures.

Module IV Heteroscedasticity- nature, consequences, detection and remedial measures. Dummy variables and lagged variables (concepts only).

References

1. Gujarati D.N. (1979). *Basic Econometrics*. McGraw Hill.
2. Hill R.C., Griffiths W.E. and Lim G.C. (2011). *Principles of Econometrics,* Fourth Edition, John Wiley & Sons.

3. Johnston J. (1984). *Econometric Models*, 3rd edition. McGraw Hill.
4. Koutsoyiannis A. (1979). *Theory of Econometrics*. Mac million Press.
5. Madnani G. M. K. (2005). *Introduction to Econometrics Principles and Applications*, 7th edition. Oxford and IBH Publishing Co. Pvt. Ltd.
6. Stock J.H. & Watson M.W. (2017). *Introduction to Econometrics*, Third Edition, Pearson, Addison Wesley.
7. Wooldridge J.M. (2018). *Introductory Econometrics: A Modern Approach*, 7th Edition, Thomson South Western

ST 1661.3: Inventory Control and Queuing Theory

Hours/Week: 3

Course Outcomes

On completion of the course, the students will be able to:

CO.1: Describe inventory control and cost associated with inventories

CO.2: Explain Economic order quantity (EOQ)

CO.3: Solve Deterministic Inventory problem with and without shortages

CO.4: Describe EOQ Problems with price breaks

CO.5: Discuss probabilistic inventory Control

CO.6: Explain Newspaper boy problem

CO.7: Discuss the basic concepts of queuing theory

CO.8: Derive the steady state solution of M/M/1 queue model

CO.9: Illustrate cost models in queuing

Module Outcomes

Sl. No:	Outcomes On completion of each module, students should be able to:	Taxonomy Level

Module: I	MO 1.1 Describe inventory control	Remember
	MO 1.2 Explain cost associated with inventories	Remember
	MO 1.3 Write factors affecting inventory control	Remember
	MO 1.4 Explain Economic order quantity (EOQ)	Understand
Module: II	MO 2.1 Explain Deterministic Inventory problem with and without shortages	Understand
	MO 2.2 Describe EOQ Problem with price breaks	Understand
	MO 2.3 Discuss probabilistic inventory Control	Understand
	MO 2.4 Explain Newspaper boy problem	Apply
Module: III	MO 3.1 Describe the basic concepts of queuing theory	Remember
	MO 3.2 Explain behaviours of queuing models	Remember
	MO 3.3 Write pure birth and Death models	Remember
	MO 3.4 Discuss classification of queuing models	Understand
	MO 3.5 Distinguish transient and steady state	Understand
	MO 3.6 Write Kolmogorov differential Equations	Understand
Module: IV	MO 4.1 Explain Poisson queues	Understand
	MO 4.2 Derive the steady state solution of M/M/1 queue model	Apply
	MO 4.3 Define Non-Poisson queuing system and give examples	Understand
	MO 4.4 Discuss cost models in queuing	Understand

COURSE CONTENT

Module I Introduction, terminologies connected with Inventory control, costs associated with Inventories, factors affecting inventory control, Economic order quantity (EOQ).

Module II Deterministic Inventory problem with no shortages, deterministic inventory problem with shortages, EOQ Problem with price breaks, Inventory problem with uncertain demand, probabilistic inventory Control. News paper boy problem.

Module III Queuing system, elements of a queuing system, operating characteristics, pure birth and Death models, classification of queuing models, transient and steady state, Kolmogorov differential Equations.

Module IV Poisson queues M|M|1 with infinite channel capacity and limited channel capacity, non-Poisson queuing system, examples, cost models in queuing.

References:

1. Gross, D. and Hariss, C.M. (2009). *Fundamentals of Queueing Theory*, John Wiley & Sons.
2. Kanthi Swarup, Gupta, P.K, and Man Mohan (2012). *Operations Research*, Sulthan Chand & Sons.
3. Sharma, J.K. (2009). *Operations Research Theory and Applications*, Macmillan India Limited.
4. Medhi J (2014) *Introduction to Queueing Systems and Applications*, New Age International Publishers.
5. Mittal, K.V. and Mohan, C. (1996). *Optimization Methods in Operations Research and System Analysis*, New Age Publishers.
6. Paneerselvam, R. (2006). *Operations Research*, Prentice Hall of India.
7. Rao S S. (1984), *Optimization Theory and Applications*, New Age Publishers, Wiley Eastern.
8. Ravindran, A., Philips, D.T. and Solberg, J. (2007). *Operations Research: Principles and Practice*, John Wiley & Sons, New York.
9. Taha, H. A. (2010). *Operations Research*, Macmillan India Limited.
10. Hamdy A Taha, (1996). *Operation Research an Introduction*. Prentice Hall of India, New Delhi.
11. Mustafi, C.K. (1996). *Operations Research Methods and Practices*. New Age International Publishers, New Delhi.

ST 1661.4: Reliability and Survival Analysis

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Understand the concepts of reliability analysis.

CO.2: Explain hazard function and reliability function.

CO.3: Evaluate the reliability of systems.

CO.4: Understand and evaluate the notion of ageing.

CO.5: Explain different lifetime distributions.

CO.6: Apply different censoring schemes.

CO.7: Explain different parametric estimators.

CO.8: Apply different regression models.

Module Outcomes

Sl. No.	Outcomes On Completion of each module, Students will be able to:	Taxonomy level
Module: I	MO 1.1 Definition of Reliability function and mean time to failure. MO 1.2 Reliability of System connected in Series, Parallel, and k out of N systems. MO 1.3 Notions of ageing- basic concepts on IFR, IFRA, NBU, and NBUE.	Understanding Evaluating Evaluating
Module: II	MO 2.1 Common life distributions-exponential, Weibull, gamma. MO 2.2 Censoring: Type I&Type II censoring.	Evaluating Evaluating
Module: III	MO 3.1 Likelihood Inference with Censored Data. Parametric models. MO 3.2 Single sample methods, Life tables. MO 3.3 Kaplan-Meier Estimator. MO 3.4 Two sample methods, log-rank test, parametric comparisons.	Evaluating Evaluating Evaluating Applying
Module: IV	MO 4.1 Regression models: covariates and their uses MO 4.2 Definition and interpretation of Cox's proportional hazard model and additive hazard model, their applications, concept of competing risks.	Evaluating Evaluating

COURSE CONTENT

Module I Definition of Reliability, hazard function, Reliability function and mean time to failure. Reliability of System connected in Series, Parallel, and k out of N systems. Notions of ageing- basic concepts on IFR, IFRA, NBU, and NBUE.

Module II Lifetime distributions; Common life distributions-exponential, Weibull, gamma. Censoring: Type I &Type II censoring.

Module III Likelihood Inference with Censored Data. Single sample methods, Life tables. Kaplan-Meier Estimator. Parametric models. Two sample methods, log-rank test, parametric comparisons.

Module IV Regression models: covariates and their uses, Definition and interpretation of Cox's proportional hazard model and additive hazard model, their applications, concept of competing risks.

References

1. Smith, P.J. (2002): *Analysis of Failure and Survival Data*. CRC.
2. Kleinbaum, D. G. and Klein, M. (2012). *Survival Analysis: A Self-Learning Text*, 3rd Ed, Springer, New York
3. Md. Rezaul Karim and M. Ataharul Islam(2019). *Reliability and Survival Analysis*, Springer,New York
4. Barlow, R. E. and Proschan, F. (1975): *Statistical theory of reliability and life testing*. Holt, Reinhart and Winston.
5. Lawless, J. F. (2003). *Statistical models and methods for lifetime data*. John Wiley & Sons.

ST 1661.5: Machine Learning

Hours/Week: 3

Course Outcomes

On completion of the course, the students should be able to:

CO.1: Download and Install Python

CO.2: Understand basic commands of Python

CO.3: Describe the functions of Python

CO.4: Describe the machine learning application

CO.5: Describe the concept of Bayesian decision theory

CO.6: Describe various clustering methods

Module Outcomes

Sl.No:	Outcomes On completion of each module, students will be able to:	Taxonomy Level
Module: I	MO1.1 Download and install Python MO 1.2 Describe commands, variables, operators and loops in Python MO 1.3 Explain the concept of function MO 1.4 Describe the role of Python in data analysis	Apply Understand Understand Remember
Module: II	MO 2.1 Outline the applications of Machine learning MO2.2 Describe the concept of supervised learning MO 2.3 Define the concept of unsupervised learning MO 2.4 Define the concept of reinforcement learning	Remember Understand Remember Remember
Module: III	MO 3.1 Describe Bayesian decision theory MO 3.2. Describe Discriminant function, Utility Theory, Association rule	Understand Understand
Module:IV	MO4.1 Explain basic regression MO 4.2 Describe k-means clustering, and nearest neighbour technique MO 4.3 Explain decision tree, random forest and neural network	Understand Understand Understand

COURSE CONTENT

Module I: Basics of Python language: Installing Python and running python scripts using IDEs, basic commands, variables, operators, conditional statements, loops. Data structures: Basics of list, tuples, sets, and dictionaries. Fundamental concepts of functions. Role of Python in statistical data analysis.

Module-II Machine learning applications, basic concepts of supervised, unsupervised learning, and reinforcement learning. Dimension of supervised learning, VC dimension.

Module-III Elementary concepts only of: Bayesian decision theory – classification, loss and risk, Discriminant functions, Utility Theory, association rules, Bayes estimator.

Module IV Basics of regression, tuning model complexity, bias/variance dilemma, Overview of the following: k-means clustering, nearest neighbor method, decision trees, neural networks, random forests (all without any derivation).

References

1. Alpaydin, E. (2009). *Introduction to Machine Learning*. MIT press.
2. Chun, W. (2006) . *Core Python Programming*. Prentice Hall Professional.
3. Daniel T. Larose (2006): *Data Mining: Methods and Models*, John Wiley and sons. (Relevant portions of Chapter 4).
4. Embarak, O. (2018). *Data Analysis and Visualization Using Python*: *Analyze Data to Create Visualizations for BI Systems*. Apress.
5. Gupta, G.K. (2008): *Introduction to Data Mining with case studies*, Prentice-Hall of India Pvt. Ltd.
6. Lambert, K. A. (2011). *Fundamentals of Python: First Programs*. Cengage Learning.
7. Trevor, H., Robert, T., & JH, F. (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. Springer
8. Tan, T., Steinbach, M. and Kumar, V. (2006): *Introduction to Data Mining*, Pearson Education.

Open Courses for other Degree Programmes

ST 1551.1: Statistics and Research Methodology

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Explain the concepts & objectives of research and formulation of research process

CO.2: Describe the role of statistics in research

CO.3: Organize and present the data collected.

CO.4: Design a questionnaire & conduct sample survey

CO.5: Explain basic concepts of testing of hypothesis

CO.6: Explain the methods of writing research reports

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO1.1 Describe the concepts and objectives of research MO 1.2 Explain the steps involving formulation of research process MO 1.3 Distinguish between types of variables MO 1.4 Identify the data types	Understand Understand Understand Analyse
Module: II	MO 2.1 Explain role of statistics in research MO 2.2 Distinguish between primary & secondary data MO 2.3 Describe methods of collecting primary data. MO 2.4 Design a questionnaire and carry out a sample survey	Understand Analyse Understand Understand
Module: III	MO 3.1 Organize & present the data. MO 3.2 Calculate mean, standard deviation. MO 3.3 Introduce the basic concepts of testing of hypothesis. MO 3.4 Explain the methods of writing research reports	Apply Apply Understand Understand

COURSE CONTENT

Module I Concept and objectives of research, types of research, research methods v/s research methodology, steps involved in scientific research, flow chart of research process, formulation of research problems, literature survey, formulation of hypothesis, preparation of research design/research plan. Variables-definition, discrete and continuous, qualitative and quantitative, subjective and objective, dependent and independent. Measurement and scaling - motivation of scaling, different types of scaling - nominal, ordinal, interval and ratio,

scaling of rates and ranks, scaling of judgements. Data - definition, univariate, bivariate and multivariate, cross-sectional and time series.

Module II Definition of statistics, role of statistics in research methodology, primary and secondary data, population and sample, sampling frame, census and sampling surveys, methods of collecting primary data, observational method, interview method, questionnaire and schedule method, local correspondents methods. Designing a questionnaire and schedule, collection of secondary data, selection of appropriate method for data collection. Sampling design, various types of sampling designs, sampling and non-sampling errors, selection of sample size, steps in sampling design, collection of data, scrutiny of data.

Module III Representation of data, classification and tabulation, bar chart, pie chart, histogram, box plot, stem and leaf diagram, frequency curve, scatter plots. Descriptive measures - mean, standard deviation, testing of hypothesis, hypothesis, types of errors, p-value, one tailed and two tailed test, Interpretation of results and report writing-meaning of interpretation, need of interpretation types of report, different steps in report writing, lay out of research report, precautions for writing research reports.

References

1. Bhattacharya and Sreenivas (1972). *Psychometrics and Behavioural Research*. Sterling Publishers, P. Ltd.

2. Gopal, M. H. (1964). *An Introduction to Research Procedure in Social Sciences*. Asia Publishing House, Mumbai.

3. Kothari, C. R. (2001). *Research Methodology-Methods and Techniques*, 2nd Ed. Viswa Prakashan, New Delhi.

4. Torgerson, W. (1958). *Theory and methods of Scaling*. John Wiley and Sons, New York.

ST 1551.2 Stochastic Processes

Hours/Week:3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Describe and exemplify concepts of stochastic processes, time space and state space, classification of stochastic processes based on the nature of time space and state space.

CO.2: Explain Markov chains: Definition, transition probability matrix, n-step transition Probability and Chapman-Kolmogorov equation

CO.3: Calculate n-step transition probabilities

CO.4: Classify states of a finite Markov chain**.**

CO.5: Distinguish between strict and weak (covariance or wide sense) stationarity,

CO.6: Describe Branching processes, offspring distribution, extinction probabilities.

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO1.1 Define probability distributions, generating functions, conditional distribution MO 1.2 Articulate and exemplify the concepts of Stochastic processes, time space and state space. MO 1.3 Construction of examples of Stochastic processes	Understand Apply Create
Module: II	MO 2.1 Articulate concepts of Markov chains, transition probability matrix, n-step transition probabilities MO 2.2 Calculate n-step transition probabilities MO 2.3 Describe and exemplify classification of states in a Markov Chain MO 2.4 Calculate the periodicity of a Markov Chain MO 2.5 Describe and exemplify: Poisson process	Understand Evaluation Understand Evaluation Understand
Module: III	MO 3.1 Distinguish between strict and weak (covariance or wide sense) stationarity MO 3.2 Describe and exemplify branching processes MO 3.3 Interpret the concept of extinction probabilities	Understand Apply Evaluate

COURSE CONTENT

Module I Collection of random variables, joint probability distributions, consistency theorem (statement only), generating function, distribution of sum of independent random variables,

conditional distribution, definition of stochastic processes-examples, state space, classification of stochastic processes with examples.

Module II Markov process, Markov chain, transition probability, stationary transition probability, Chapman-Kolmogorov equation (proof not required), stochastic matrix, classification of states recurrent, transient and periodic, properties, closed set of states, stationary distribution and ergodic theorem (statement only). Poisson process-postulates, definition, examples, inter arrival times - its distributions, relation of Poisson process with binomial and uniform distribution, compound Poisson process-definition, examples and applications.

Module III Stochastic process with stationary and independent increments, stationary process-wide sense and strict sense, gaussian process. Time series, components of time series, first order auto regressive process, auto correlation. Branching process-definition, discrete time and discrete state branching process-examples, probability generating function, probability of extinction.

Text Books and References

1. Bailey, N. T. J. (1964). *Elements of Stochastic Process with Applications to the Natural Sciences*. Wiley, New York.

2. Bartlett, M. S. (1955). *An Introduction to Stochastic Processes*. Cambridge University Press.

3. Box, G. E. P and Jenkins, G. M. (1976). *Time Series Analysis: Forecasting and Control*. Holden- Day, San Francisco.

4. Medhi, J. (1984). *Stochastic Processes.* Wiley Eastern Ltd, New Delhi.

5. Samuel Karlin & Howard Taylor (1972). *A First Course in Stochastic Process*. Academic Press, NewYork

ST 1551.3: Design of Experiments

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Explain the concept of design of experiments

CO.2: Identify estimability of a linear parametric function

CO.3:Apply Gauss-Markov theorem for finding BLUE of a parametric function

CO.4: Explain the principles of experimentation.

CO.5: Perform one-way and two-way analysis of variances

CO.6: Design and analyse CRD, RBD, LSD

CO.7: Perform missing plot analysis in RBD and LSD

Module Outcomes

Sl. No.	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module:I	MO1.1Explain the concept of design of experiments MO 1.2 Identify estimability of a linear parametric function MO 1.3 Apply Gauss-Markov theorem for finding BLUE of a parametric function. MO 1.4 Explain the principles of experimentation	Understand Understand Apply Understand
Module:II	MO 2.1 Define ANOVA MO 2.2 State uses of ANOVA and assumptions MO 2.3 State the model for one way and two way classification MO 2.4 Describe ANOVA Tables MO 2.5 Perform one way and two analysis of variance	Remember Remember Remember Understand Apply
Module: III	MO 3.1 Define CRD and state its advantages MO 3.2 Design and analyze CRD MO 3.3 Define RBD and state its advantages MO 3.4 Design and analyze RBD MO 3.5 Define LSD and state its advantages MO 3.6 Design and analyze LSD MO 3.7 Analysis of RBD and LSD with missing values	Remember Apply Remember Apply Remember Apply Apply

COURSE CONTENT

Module I Concepts of design of experiments, linear estimation, estimability of parametric function, Gauss-Markov setup, Gauss-Markov theorem, need for design of experiments, principles of experimentation-randomization, replication and local control.

Module II Meaning of Analysis of variance (ANOVA), uses and assumptions**,** one way and two-way classification models, ANOVA tables.

Module III Basic designs: C.R.D and R.B.D lay out, missing plot techniques for one missing observation. L.S.D layout, missing plot technique for one missing observations.

References

1. Das and Giri. (1979). *Design and Analysis of Experiments*. New Age International (P) Ltd.
2. S. C. Gupta and V.K. Kapoor (2002). *Fundamentals of Applied Statistics*. Sultan Chand & Co. New Delhi.
3. Montgomery, C.J. (1976). *Design and Analysis of Experiments*, Wiley Eastern.
4. Joshi, D.D. (1987). *Linear Estimation and Design and Analysis of Experiments*, Wiley Eastern.

ST 1551.4: Official Statistics

Hours/Week: 3

Course Outcomes

On completion of the course, the students will be able to:

CO.1: Explain the present official statistical system in India.

CO.2: Describe the functions and activities of central and State statistical organisations.

CO.3: Describe index numbers and its application and apply the various methods of constructing index numbers.

CO.4: Construct Consumer price index.

CO.5: Explain time series analysis and develop time series models.

Module Outcomes

Sl. No:	Outcomes On completion of each module, students will be able to:	Taxonomy Level

Module: I	MO 1.1 Explain the role, function and activities of central and State statistical organizations with special emphasis on the role of Ministry of Statistics & Program Implementation, and NSO MO1.2 Explain theorganization of large scale sample surveys. MO1.3 Explain thegeneral and special data dissemination systems.	Understand Understand Understand
Module: II	MO 2.1 Explain index numbers and its application. MO 2.2 Distinguish Price relatives and quantity or volume relatives, link and chain relatives. MO 2.3 Explain simple aggregative and weighted average methods. MO 2.4Apply the various methods of constructing index numbers. MO 2.5 Construct Consumer price index.	Apply Understand Understand Apply Apply
Module: III	MO 3.1 Explain the basic concepts of time series analysis. MO 3.2 Develop time series models. MO 3.3 Determine trend and growth curves. MO 3.4 Analyze seasonal fluctuations. MO 3.5 Construct seasonal indices.	Understand Apply Apply Apply Apply

COURSE CONTENT

Module I Introduction to Indian statistical systems: role, function and activities of central and State statistical organizations. Role of Ministry of Statistics & Programme Implementation, National Statistical Office. Organization of large-scale sample surveys. General and special data dissemination systems.

Module II Index numbers - its definition, application of index numbers, price relatives and quantity or volume relatives, link and chain relatives. Problems involved in computation of index numbers. Use of averages, simple aggregative and weighted average methods. Laspeyre's, Paasche's and Fisher's index numbers. Time and factor reversal test of index numbers. Consumer price index.

Module III Time series-definition, its different components, illustrations, additive and multiplicative models, determination of trend, growth curves, analysis of seasonal fluctuations, construction of seasonal indices.

References:

1. Chat filed, C. (1980). *The Analysis of Time Series-An Introduction*. 2nd Ed., Chapman and Hall.

2. Goon, A. M., Gupta, M. K and Desgupta, B. (1986). *Fundamentals of Statistics*; Vol.II. World Press, Calcutta.

3. Mukhopadhay, P. (1999). *Applied Statistics*. New Central Book Agency Pvt. Ltd. Calcutta.

4. Basic Statistics Relating to the Indian Economy (CSO) 1990.

5. Guide to Official Statistics (CSO) 1995.

6. Statistical System in India (CSO) 1995.

ST 1551.5: Time Series and Forecasting

Hours/Week:3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Understand the concepts of time series.

CO.2: Evaluate the components of time series.

CO.3: Understand and apply forecasting techniques.

CO.4: Explain different models of time series.

CO.5: Apply computation techniques and its interpretations.

Module Outcomes

Sl. No.	**Outcomes** On Completion of each module, Students will be able to:	**Taxonomy level**
Module: I	MO 1.1 Constructs the decomposition of a Time Series	Applying

	MO 1.2 Evaluates the secular trend of a time series using methods like method of fitting mathematical curves, Method of moving averages	Evaluating
Module: II	MO 2.1 Evaluates the Seasonal fluctuations of time series using Method of simple Averages, Ratio to trend method, Ratio to Moving average method and Link relative method	Evaluating
Module: III	MO 3.1 Business forecasting MO 3. 2 Forecasting using linear trend, regression, ARIMA models. MO 3.3 Computation and interpretation of forecasting	Understanding Evaluating Applying

COURSE CONTENT

Module I Time series analysis, utility of time series data-four components, adjustments for various changes, models of time series. Estimation of trend-methods-freehand drawing, semi-averages, moving averages, least squares (linear, quadratic and exponential)-Detrending a time series.

Module II Estimation of seasonal variation-methods of construction of seasonal index-average method, ratio to trend method, link relative method, Depersonalization. Estimation of cyclical variation-residual method, direct method, reference cycle analysis method, harmonic analysis method. Estimation of irregular variations.

Module III Business forecasting and its importance, Methods of forecasting, linear trend, regression (single & double), ARIMA models (Box-Jenkins method-not to be examined). Computer based forecasting (understanding of the use of software in analysis). Interpretation of outputs expected.

References

1. D. N. Elhance, Veena Elhance & B. M. Agarwal, Kitab (1995). *Fundamentals of Statistics*, Mahal Publications.

2. S. C. Gupta & V. K. Kapoor (2002), *Fundamentals of Applied Statistics*, Sultan Chand & Sons.
3. Parimal Mukhophadyay (1998). *Applied Statistics*.
4. G. V. Shenoy &Madan Paul, *Statistical Methods in Business and Social Sciences*.

ST 1551.6: Statistics for Psychology and Education

Hours/week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: State main ideas about the concepts of basic Statistics.

CO.2: Prepare a questionnaire and conduct a sample survey.

CO.3: Describe of various Statistical tools.

CO.4: Express some ideas about the applications of Statistics in different areas of psychological studies.

CO.5: Calculate the various measures of correlation coefficient.

Module Outcomes

Sl. No:	**Outcomes** On completion of each module, students will be able to:	**Taxonomy Level**
Module: I	MO1.1Explain the need, scope and limitations of statistics	Understand
	MO 1.2 Outline the elements of sample survey.	Remember
	MO 1.3 Prepare a questionnaire	Apply
	MO 1.4 Classify scales of measurements into nominal, ordinal, interval and ratio	Understand
	MO 1.5 Define derived scores	Remember
	MO 1.6 Articulate the concepts of translating raw scores to standard scores	Understand
	MO 1.7 Articulate the concept of score transformation	Understand
	MO 1.8 Define percentile scores	Remember

	MO 1.9 Articulate the concept of comparability of scores MO 1.10 Define normalized standard scores. MO1.11 Discuss the methods of estimating reliability and factors affecting reliability.	Understand Remember Understand
Module: II	MO2.1 Compute the correlation techniques applied in evaluation of test materials MO 2.2 Compute the Karl Pearson's coefficient of correlation and Spearman's rank correlation. MO2.3 Memorize Biserial correlation, point biserial correlation, tetrachoric correlation, partial correlation and phi coefficient.	Apply Apply Remember
Module: III	MO3.1 Explain the chi-square test (test of association) and contingency coefficient MO 3.2 Explain Fisher's exact test, Yule's Q-tests of hypothesis, basic concepts (an overview of parametric and non-parametric tests). MO 3.3 Explain sign tests, run test, median test, Mann-Whitney U test and Wilcoxon signed rank test MO 3.4 Interpret the results obtained to describe above.	Understand Understand Understand Apply

COURSE CONTENT

Module I Introduction-scope and limitations of statistics, elements of sample survey, preparation of questionnaire, variables and constants-scales of measurements-derived scores-translating raw scores to standard scores - score transformation, percentile scores, comparability of scores, normalized standard scores, methods of estimating reliability, factors affecting reliability.

Module II Correlation techniques applied in evaluation of test materials, Karl Pearson's coefficient of correlation, Spearman's rank correlation, biserial correlation, point biserial correlation, tetrachoric correlation, partial correlation, phi coefficient.

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Module III Tests of association - chi-square-contingency coefficient, Fisher's exact test, Yule's Q-tests of hypothesis, basic concepts (an overview of parametric and nonparametric tests). Nonparametric tests: sign tests; run test; median test; Mann-Whitney U test; Wilcoxon signed rank test (Interpretation of results expected).

References

1. Y. P. Agarwal (1986). *Statistical Methods, Concepts, Application and Computation*, Sterling Publications.
2. Edward. W. Minium, Bruce. M. King, GordenBear (2002). *Statistical Reasoning in Psychology and Education.* John Wiley and Sons.

*3.*H. E. Garrett (2006). *Statistics in Psychology & Education.*

ST 1551.7: Econometric Methods

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Describe simple and multiple linear regression models and its assumptions.

CO.2: Apply principle of least square method to estimate the parameters in simple and multiple linear regression models.

CO.3: Identify multi collinearity problem and its consequences.

CO.4: Describe generalized least square method of estimation.

CO.5: Understand the test for autocorrelation

CO.6: Understand the role of dummy variable and lagged variable

Module Outcomes

Sl.No	**Outcomes** On completion of each module, students will be able to	**Taxonomy level**

Module: I	MO 1.1 Explain econometric concepts and techniques	Understand
	MO 1.2 Describe normal distribution and its properties	Understand
	MO 1.3 Explain simple linear regression model	Apply
	MO 1.4 Describe Simple and multiple correlation	Understand
	MO 1.5 Describe least square estimators.	Understand
Module: II	MO 2.1 Explain simple linear regression model	Analyse
	MO 2.2 Describe Least square and maximum likelihood method of estimation	Understand
	MO 2.3 Explain inference regarding simple linear regression parameters	Apply
Module: III	MO 3.1 Explain multiple linear regression models	Understand
	MO 3.2 Explain inference regarding multiple regression parameters	Analyse
	MO 3.3 Define multicollinearity	Remember
	MO 3.4 Describe method of Generalised least squares.	Understand
	MO 3.5 Explain test for autocorrelation	Understand
	MO 3.6 Explain the concept of dummy and lagged variables	Understand

COURSE CONTENT

Module I Basic concepts, definition and scope of econometric methods, economic models, examples, types of variables. Normal distribution-definition and properties, correlation and regression-simple and multiple, least square method of estimation.

Module II Simple linear model, estimation of parameters, ordinary least square method, maximum likelihood method, properties of estimators, confidence interval and hypothesis testing.

Module III General linear model-assumptions, least square estimators, confidence interval and hypothesis testing, multicollinearity-meaning and consequences. Generalized least square

estimators, auto correlation, tests for autocorrelation, heteroscedasticity, dummy variables and lagged variables (concepts only).

References

1. Gujarathi, D. (1979). *Basic Econometrics*. McGraw Hill.
2. Johnston, J. (1984). *Econometric Models*, 3rd edition. McGraw Hill.
3. Koutsoyiannis, A. (1979). *Theory of Econometrics*. Mac million Press.
4. Madanani, G. M. K. (2005). *Introduction to Econometrics Principles and Applications*, 7th edition. Oxford and IBH Publishing Co. Pvt. Ltd.

ST 1551.8: Essential Statistics for Social Sciences

Hours/week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Describe the importance of Statistics in social research

CO.2: Define the main steps in conducting a sample survey

CO.3: Prepare diagrams and graphs to represent frequency tables

CO.4: Compute the different measures of central tendency and variability of a given data

CO.5: Explain the relation between two variables using correlation and regression

CO.6: Express the concept of probability and define some basic probability distributions

CO.7: Discuss the basic concepts regarding testing of hypothesis

CO.8: Explain the uses of various non-parametric tests

Module Outcomes

Sl.No.	**Outcomes** On completion of each module, students will be able to:	**Taxonomy level**
Module: I	MO 1.1 Describe the important applications of Statistics in social research	Remember
	MO 1.2 Outline the main steps involved in conducting a sample survey	Remember
	MO 1.3 Summarize the points to be remembered while preparing a questionnaire	Understand

	MO 1.4 Discuss the concepts of classification and tabulation	Understand
	MO 1.5 Prepare suitable diagrams and graphs to represent frequency tables	Apply
Module: II	MO 2.1 Compute the measures of central tendency of a given data	Apply
	MO 2.2 Explain the concept of percentiles	Understand
	MO 2.3 Compute the different absolute and relative measures of dispersion	Apply
	MO 2.4 Write the simple linear regression equations corresponding to given bivariate data	Apply
	MO 2.5 Compute the coefficients of correlation between variables based on bivariate data	Apply
Module: III	MO 3.1 Express the concept of probability	Understand
	MO 3.2 Define binomial, Poisson and normal distributions	Remember
	MO 3.3 Explain the concept of association between variables	Understand
	MO 3.4 Explain the basic concepts regarding testing of hypothesis.	Understand
	MO 3.5 Describe the uses of some nonparametric tests	Remember

COURSE CONTENT

Module I Basic Statistics, definition and functions of Statistics, Importance of Statistics to social research, elements of sample survey, preparation of questionnaire, opinion polls, Gallop polls, etc. Classification and tabulation-frequency tables and its diagrammatic & graphical representations.

Module II Measures of central tendency-mean, median, mode, percentiles and percentile score. Measures of variability, absolute and relative measures, correlation and regression.

Module III Simple concepts of probability. Binomial, Poisson and Normal distributions. (Simple problems and basic concepts without derivations), Contingency tables &coefficients

of association, interpretation of results, Basic concepts of testing of hypothesis, concepts of parametric-non parametric tests, non-parametric tests- Sign test (one sample and two samples), Run, Median, Wilcoxon sign test, K-S test (one sample and two samples), Kruskal-Wallis test, Friedman two way analysis of variance (names and uses only without any problem and derivation)

References

1. Blalock H.M. and Blalock A.B. (1968). *Methodology in Social Research*. McGraw Hill
2. Elifson K.W., Runyon R.P. &Haber A. (1998). *Fundamentals of Social Statistics*. 3rd Ed. Mc Graw Hill – International edition.
3. Gillespie D. F.& Glisson C. (1992). *Quantitative methods in Social Work*: State of the art. Binghamton
4. Weinbach R. W. & Grinnell R. M. (1997). *Statistics for Social Workers*. New York: Longman.

ST 1551.9: Statistics for Humanities

Hours/Week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Explain the history and scope of statistics & describe the steps involving a statistical survey.

CO.2: Prepare a questionnaire.

CO.3: Collect primary & secondary data.

CO.4: Construct the diagrams and graphs for a given dataset (s).

CO.5: Compute & compare measures of central tendency & dispersion.

CO.6: Compare correlation &association.

CO.7: Compute and interpret test of association of attributes.

Module Outcomes

Sl. No:	Outcomes On completion of each module, students should be able to:	Taxonomy Level

Module: I	MO 1.1 Recall the history, functions, limitations and scope of statistics in various fields. MO 1.2 Describe the steps involved in a statistical survey MO 1.3 Explain the methods of collecting primary data. MO 1.4 Explain the sources and precautions to be included in the collection of secondary data. MO 1.5 Consider the points to be remembered while framing a questionnaire.	Remember Understand Understand Understand Remember
Module: II	MO 2.1 Explain the various types of classification. MO 2.2 Construct frequency distribution. MO 2.3 Identify and construct the diagrams and graphs for a given dataset (s).	Understand Apply Apply
Module: III	MO 3.1Compute measures of central tendency, Absolute and relative measures of dispersion. MO 3.2 Compare the performance and consistency of given datasets. MO 3.3 Construct and interpret Lorenz curve for the dataset(s). MO 3.4 Distinguish between correlation & association. MO 3.5 Compute and interpret Karl Pearson's &Spearman's coefficient of correlation. MO 3.6 Compute and interpret test of association of attributes.	Apply Apply Apply Analyze Apply Apply

COURSE CONTENT

Module I Statistics-introduction-origin & growth of statistics, function of statistics, scope of statistics, statistical methods, statistics & computers - organizing a statistical survey, introduction, planning the survey, executing the survey. Collection of data - introduction, primary & secondary data, methods of collecting primary data, preparation of questionnaire, source of secondary data, editing primary and secondary data.

Module II Classification and tabulation of data: meaning and objective of classification, types of classification, tabulation of data, types of tables. Formation of discrete and continuous frequency distribution. Diagrammatic and graphic representation of data. Significance of diagrams and graphs. General rules for constructing diagrams.

Module III Descriptive Statistics: Measures of central tendency, measures of variation (absolute and relative measures). Lorenz curve. Correlation - scatter diagram, Karl Pearson's coefficient of correlation, Spearman's coefficient of correlation, association of attributes and their tests of association.

References

1. Blalock, H. M and Blalock, (1971). *Methodology in Social Research*., Mc Graw-Hill.
2. D. N Elhance, Veena Elhance and B. M Agarwall. Kitab (1995). *Fundamentals of Statistics*. Mahal Publications.
3. G. V. Shenay, Madan Pant.*Statistical Methods in Business and Social sciences*. Macmillan India Ltd.
4. Kothari, C. R. (2001). *Research Methodology-Methods and Techniques*, 2nd Ed. Viswa Prakashan, New Delhi.
5. Torgerson, W. (1958). *Theory and methods of Scaling*. John Wiley and Sons, New York.

ST 1551.10: Geostatistics

Hours/Week: 3

Course Outcomes

On completion of the course, the students will be able to:

CO.1: Explain the elementary principles of Statistics such as measures of central tendency, absolute and relative measures of dispersion.

CO.2: Identify statistical methods generally used in Earth Sciences.

CO.3: Use statistical tools for analysis of data from different areas of geosciences.

CO.4: Carry out test of hypothesis.

Module Outcomes

Sl. No:	Outcomes On completion of each module, students will be able to:	Taxonomy Level
Module: I	MO 1.1 Distinguish between primary and secondary data.	Understand
	MO 1.2 Distinguish between quantitative and qualitative data.	Understand
	MO 1.3 Define and compute mean, median, mode, range, standard deviation and coefficient of variation.	Apply
	MO 1.4 Define relative measures of dispersion.	Remember
	MO 1.5 Compute correlation coefficient.	Apply
	MO 1.6 Construct regression lines for data sets	Apply
Module: II	MO 2.1 Define classical and frequency definition of probability	Understand
	MO 2.2 State Addition, multiplication and Bayes' theorems.	Understand
	MO 2.3 Compute probabilities	Apply
	MO 2.4 Define Random variable and its expectation.	Understand
	MO 2.5 Explain binomial, Poisson and normal distributions.	Understand
Module: III	MO 3.1 Distinguish between large and small sample tests.	Understand
	MO 3.2 Test mean and variance corresponding to single population.	Apply
	MO 3.3 Test equality of means and variances of two populations.	Apply
	MO 3.4 Describe discriminant analysis, cluster analysis, factor analysis	Remember

COURSE CONTENT

Module I: Concepts of primary data and secondary data, population and sample; basic steps in statistical study. Data- quantitative and qualitative. Measures of central tendency- mean, median and mode. Measures of dispersion-range and standard deviation. Relative measure of dispersion-coefficient of variation.Illustration using geological and geographical data. Scatter diagram, Correlation, least square methods (concept only) and Construction of regression lines for data sets.

Module II: Random experiments, sample space, events, definition of probability-classical and relative frequency definition. Addition and multiplication theorem (statement only). Bayes' theorem (statement only) and applications. Random variable and mathematical expectation. Basic distributions-binomial, Poisson and normal (basic concepts only). Illustration using geological data.

Module III: Basic concepts of statistical inference-statistical hypothesis, simple and composite hypothesis, two types of errors, significance level, p-value. Large sample tests and small sample tests for population mean, variance (one or two sample)-concept and simple problems only. Analysis of variance: one way and two-way classification - concept only. Analysis of multivariate data: discriminant analysis, cluster analysis, factor analysis (basic concepts and examples).

References:

1. Cheeney, R. F (1983). *Statistical Methods in Geology*.

2. Davis, J. C. (2002). *Statistics and Data Analysis in Geology*. 3rd Ed. John Wiley (Chapters 2, 4 & 6).

3. Miller, R. L. and Khan, T. S. (1962*). Statistical Analysis in the Geological Analysis*. Wiley

4. Nebendu Pal and Sahadeb Saikar (2008). *Statistics Concepts and Applications*. Prentice Hall of India. Chapters (1, 2, 3, 4, 5).

ST 1551.11: Data Analysis

Hours/week: 3

Course Outcomes

On completion of the course, students should be able to:

CO.1: Calculate the various measures of central tendency and dispersion, correlation coefficient.

CO.2: Distinguish between partial and multiple correlation.

CO.3: Realize the difference between simple and multiple regression.

CO.4: Use R for statistical data analysis.

CO.5: Analyze data using R and understand the insights from it.

CO.6: Familiarize the uses of various parametric and non-parametric tests.

Module Outcomes

Sl. No:	Outcomes On completion of each module, students will be able to:	Taxonomy Level
Module: I	MO 1.1 Classify and tabulate the given data. MO 1.2 Apply various diagrammatic and graphical tools to represent a given data. MO 1.3 Demonstrate the use of R. MO 1.4 Describe the stages of processing interpretations. MO 1.5 Define measures of central tendency, measures of dispersion, skewness, kurtosis and correlation .	Understand Apply Apply Understand Remember
Module: II	MO 2.1 Distinguish between partial and multiple correlation. MO 2.2 Realize the difference between simple and multiple regression. MO 2.3 Describe testing the significance of partial and multiple correlation.	Understand Understand Understand
Module: III	MO 3.1 Memorise the normal test MO 3.2 Memorise the chi-square test (parametric) MO 3.3 Memorise the t-test, F-test MO 3.4 Outline the features of ANOVA (one way and two way). MO 3.5 Memorise the chi square test (non-parametric) MO 3.6 Explain the Mann-Whitney test, Wilcoxon test, Kruskal-Wallis test and Friedman test.	Remember Remember Remember Remember Remember Understand

COURSE CONTENT

Module I Classification, tabulation, charts, graphical representation, use of statistical package R to describe the above, stages of processing interpretations, computation of statistical constants, measures of central tendency, measures of dispersion, skewness, kurtosis, correlation, interpretations.

Module II Partial and multiple correlation, simple and multiple regression, testing the significance of partial and multiple correlation.

Module III Parametric tests - normal test, chi-square test, t-test, F-test, ANOVA (one way and two way). Nonparametric tests-chi square test, Mann-Whitney test, Wilcoxon test, Kruskal-Wallis test, Friedman test.

References

1. Agarwal, B. L (2009). *Basic Statistics*. Wiley Eastern, Ltd. New Delhi.
2. Dalgaard, P.(2008). *Introductory Statistics with R*, Springer, New York.
3. Gupta, S. C and Kapoor, V. K. (2002). *Fundamentals of Mathematical Statistics*, 11th Ed. Sultan Chand & Sons, New Delhi.
4. Gupta, S. P (2011). *Statistical Methods*. Sultan Chand & Sons, New Delhi.
5. Kerns, G J. (2010). *Introduction to Probability and Statistics using R.*

Web Resources:

1. https://cran.r-project.org
2. https://cran.r-project.org/manuals.html
3. https://www.r-project.org/other-docs.html
4. https://journal.r-project.org/
5. https://www.r-bloggers.com

UNIVERSITY OF KERALA

First Degree Programme under CBCSS

Scheme and Syllabus (Outcome Based Education) of Complementary STATISTICS for B. Sc. Mathematics Core

(with effect from 2022 Admission)

The syllabus is designed with an aim to equip the students with the major concepts and methods of Statistics along with the tools required to implement them in practical situations. The syllabus is prepared in accordance with the Outcome Based Education (OBE) paradigm. The curriculum is dispensed using a combination of classroom teaching, discussions, presentations, practicals, assignments, class tests etc. The syllabus has been designed to stimulate the interest of the students in Statistics and prepared in order to equip the students with a potential to contribute to the academic and industrial requirements of the society. Emphasis is given to understand the basic concepts and data analysis tools. There are practical sessions in each semester. Numerical problems solving using scientific calculators is also included in the End Semester Examination (ESE) of Courses in the semesters I, II, III & IV. Statistical computation with R is introduced which would help the students for analyzing data by making optimum usage of time and resources. For practical classes, there shall be one faculty member in charge of every 16 students (based on sanctioned strength), in accordance with the University regulations. There will be one ESE of 2 hours duration on practical using R in Semester IV.

It is mandatory to submit a duly certified Record book of practical sheets, consisting of printout of numerical problems, their R codes and results, for appearing for ESE of practical course. ESE of the practical course with a maximum of 60 marks will be held under the supervision of External Examiners duly appointed by the University. The External Examiner will also evaluate the Record books of practical work done at Lab for 20 marks.

Course Structure:

Semester	Course Code	Title of the course	Hours/ week		No. of credits	Total Hrs/ Semester	ESE Duration	Weightage In %	
			L	P				CE	ESE
I	ST 1131.1	Descriptive Statistics and Bivariate Analysis	2	2	2	72	3 hrs	20	80
II	ST 1231.1	Probability and Random Variables	2	2	2	72	3 hrs	20	80
III	ST 1331.1	Statistical Distributions	3	2	3	90	3 hrs	20	80
IV	ST 1431.1	Statistical Inference	3	2	3	90	3 hrs	20	80
	ST 1432.1	Practical using R			4		2 hrs	20	80

L – Lecture hour; P- Practical (Lab) hour

Semester - I

Course - I

ST 1131.1: Descriptive Statistics and Bivariate Analysis

Credits: 2

Hours/week: 4 (L-2, P-2)

Course Outcomes

On completion of the course, students will be able to:

CO.1: Explain the concepts of statistical surveys, sampling, census and various sampling methods like simple random sampling, systematic sampling, and stratified sampling.
CO.2: Design questionnaires and carry out surveys.
CO.3: Collect and present raw data using frequency tables as well as appropriate graphs.
CO.4: Summarize data using various measures of central tendency, dispersion, skewness and kurtosis.
CO.5: Explain the concepts of scatter diagram, correlation and calculate the correlation between two variables.
CO.6: Explain the concept of regression, fit various regression equations to given data sets and predict values of response variables.
CO.7: Explain various concepts associated with the two regression lines and identify the regression lines for given data sets.
CO.8: Practicals: Use R built in functions to solve numerical problems associated with topics covered in Modules I and II.

Module Outcomes

Sl. No:	**Outcomes**		**Taxonomy Level**
	On completion of each module, students should be able to:		
MODULE 1 Part B	MO 1.1	Define various scales of data	Remember
	MO 1.2	Distinguish between primary and secondary data	Understand
	MO 1.3	Articulate concepts of statistical surveys, sampling, and census	Understand
	MO 1.4	Define various methods of sampling	Remember
	MO 1.5	Design a questionnaire and carry out a simple survey	Understand
	MO 1.6	Construct various frequency tables	Create
MODULE 2	MO 2.1	Calculate the various measures of central tendency, dispersion, skewness and kurtosis.	Apply

	MO 2.2	Compare the merits and demerits of various measures of central tendency and dispersion.	Understand
	MO 2.3	Describe certain theoretical properties of the measures of central tendency, measures of dispersion and moments	Understand
	MO 2.4	Compare various data sets based on measures of central tendency, dispersion, skewness and kurtosis.	Evaluate
MODULE 3	MO 3.1	Explain concepts of scatter diagram, correlation and regression.	Understand
	MO 3.2	Apply principle of least squares to fit various curves	Apply
	MO 3.3	Fit various curves to data sets	Apply
MODULE 4	MO 4.1	Construct regression lines for data sets.	Apply
	MO 4.2	Identify regression lines	Analyze
	MO 4.3	Calculate angle between lines, point of intersection etc.	Analyze
	MO 4.4	Calculate Pearson's coefficient of correlation, Spearman's rank correlation coefficient and interpret the results.	Evaluate
	MO 4.5	Coefficient of determination and coefficient of alienation	Remember
MODULE 5 (Only for Practical Exam)	MO 5.1	Use built in R functions: (i) For representing data using diagrams and graphs. (ii) For calculating the various measures of descriptive statistics	Apply

Course Content

Module I:

Part A: **Introduction (Not for Examination Purpose):** Definition and significance of Statistics, Limitations and misuse of Statistics, Official Statistical system of India. Types of Data: Concepts of primary data and secondary data, population, and sample; Classification of data based on geographic, chronological, qualitative and quantitative characteristics.

Part B: Collection and Presentation of Data: Scales of data-nominal, ordinal, interval and ratio. Methods of collection of primary data–Preparation of questionnaires / schedules. Secondary data – major sources and limitations; Census and Sample Surveys; Methods of sampling ***(concepts only):*** Probability and non-probability sampling, simple random sampling with replacement (SRSWR) & simple random sampling without replacement (SRSWOR), Systematic sampling and Stratified sampling; sampling and non-sampling errors; Classification and tabulation - Construction of tables with one or more factors of classification, frequency distributions, relative and cumulative frequency distributions.

Module II:

Summarization of Data: Central tendency- mean, median, mode, geometric mean, harmonic mean; properties of arithmetic mean and median; Relationship between AM, GM and HM; Absolute and relative measures of dispersion: Range, quartile deviation, mean deviation and standard deviation; Properties of mean deviation, standard deviation, combined mean and combined standard deviation;

coefficient of variation; moments - raw and central moments; relationship between raw and central moments; effect of change of origin and scale; skewness, kurtosis and their measures.

Module III:
Bivariate data: Scatter diagram, fitting of curves- Principle of least squares, fitting of straight line $y = ax + b$, fitting of curves: $y = ax^2 + bx + c, a \neq 0$, $y = ab^x$, $y = ax^b$, $y = ae^{bx}$.

Module IV:
Karl Pearson's coefficient of correlation, Spearman's rank correlation coefficient, regression lines and prediction, coefficient of determination and coefficient of alienation (definition only)

Module V: (only for Practical Exam)
Basics of R (as given in Practical Sheet - 1); Practical based on Modules I & II – Data analysis: presentation of data – charts and diagrams, calculation of descriptive statistics, moments, measures of skewness and kurtosis.

References:

1. Agarwal, B.L. (2006). *Basic Statistics*. 4th Edition, New Age international (P) Ltd., New Delhi.
2. Gupta S. P. (2004). *Statistical Methods.* Sultan Chand & Sons, New Delhi.
3. Gupta, S. C., and Kapoor, V. K. (1994). *Fundamental of Mathematical Statistics.* Sultan Chand & Sons, New Delhi.
4. Kenny J. F (1947). *Mathematics of Statistics Part One*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
5. Kenny J. F & Keeping E. S (1964). *Mathematics of Statistics –Part Two*. 2nd Edition, D. Van Nostard Company, New Delhi-1.
6. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.

Semester – II

Course - II

ST 1231.1: Probability and Random Variables

Credits: 2

Hours/week: 4 (L-2, P-2)

Course outcomes

On completion of the course, the students should be able to:

CO.1: Distinguish between random and non-random experiments.
CO.2: Evaluate the probabilities of events using classical, statistical and axiomatic approaches.
CO.3: Identify independent events; calculate conditional probability and application of Bayes' theorem.
CO.4: Distinguish between discrete and continuous random variables with its probability distributions.
CO.5: Assess the independence of random variables.
CO.6: Calculate moment generating function and characteristic function.
CO.7: Determine the conditional mean and variance of a random variable.
CO.8: Evaluate the correlation between two random variables.
CO.9: Practical: Use R built in functions to solve numerical problems associated with topics covered in modules III and IV of ST 1131.1 (of Semester -I)

Module Outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1	MO 1.1	Distinguish between Random and non-random experiments	Understand
	MO 1.2	Explain the concepts of sample space, types of events and algebra of events	Understand
	MO 1.3	Describe the probabilities of events using classical, statistical and axiomatic approaches.	Apply
	MO 1.4	Identify mutually exclusive and exhaustive events	Understand
	MO 1.5	Define equally likely events	Remember
MODULE 2	MO 2.1	Determine the conditional probability and apply multiplication theorem	Evaluate
	MO 2.2	Explain the concepts of independence of events	Analyze
	MO 2.3	Use Bayes' theorem to evaluate posterior probabilities	Apply
MODULE 3	MO 3.1	Explain the concept of random variables	Understand
	MO 3.2	Distinguish between the discrete and continuous random variables and find its probability distributions	Analyze
	MO 3.3	Evaluate marginal and conditional distributions of bivariate random variables	Evaluate
	MO 3.4	Check for the independence of random variables	Analyze
	MO 3.5	Apply the concepts of transformation of univariate random variables	Analyze
MODULE 4	MO 4.1	Explain the concepts of mathematical expectation and its properties.	Understand
	MO 4.2	Determine the mathematical expectation of a discrete and continuous random variable	Apply
	MO 4.3	Calculate the conditional mean and variance of bivariate distributions	Apply
	MO 4.4	Explain the basic concepts of moment generating function and characteristic function	Apply

	MO 4.5	Evaluate the covariance and correlation coefficient of two random variables.	Apply
MODULE 5 (only for Practical Exam)	MO 5.1	Use built in R functions to solve numerical problems corresponding to modules III and IV of ST 1131.1 of Sem-1	Apply

Course content

Module I:
Random experiments - sample space and sample point; Events-algebra of events, concepts of equally likely, mutually exclusive and exhaustive events.
Probability: Statistical regularity, classical approaches, Axiomatic approach, theorems in probability, probability space.

Module II:
Conditional probability, multiplication theorem, independence of two and three events, compound probability, Bayes' theorem and its applications.

Module III:
Random variables - discrete and continuous, probability mass function and probability density function, distribution function, joint distribution of two random variables, marginal and conditional distributions, independence, transformation of variables-one-to-one transformations - univariate case only.

Module IV:
Expectation of random variables and its properties, theorems on expectation of sums and product of independent random variables, conditional expectation, moments, moment generating function, characteristic function, their properties and uses; bivariate moments, Cauchy- Schwartz inequality and correlation coefficient.

Module V: Practical (Numerical Problems) based on Modules III & IV of ST 1131.1 (Sem.1) – Scatter diagram, curve fitting, measures of correlation, regression analysis.

References

1. Bhat B. R. (1985). *Modern Probability Theory*. New Age International (P) Ltd, New Delhi.
2. Gupta, S. C., and Kapoor,V. K. (1994). *Fundamentals of Mathematical Statistics.* Sultan Chand & Sons. New Delhi.
3. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.

4. Pitman, J. (1993). *Probability*. Narosa Publishing House, New Delhi.
5. Rao C. R. (1973). *Linear Statistical Inference and its Applications*. 2nd edition, Wiley, New York.
6. Rohatgi V. K. (1993). *An Introduction to Probability Theory and Mathematical Statistics*. Wiley Eastern, New Delhi.

Semester – III

Course - III

ST 1331.1: Statistical Distributions

Credits: 3

Hours/week: 5 (L-3, P-2)

Course Outcomes

On completion of the course, students will be able to:

CO.1: Define various discrete and continuous standard distributions and explain their theoretical properties.
CO.2: Solve numerical problems associated with discrete and continuous standard distributions.
CO.3: Fit binomial, Poisson and normal distributions to data sets and calculate theoretical frequencies.
CO.4: Explain the laws of large numbers and apply them to solve numerical problems
CO.5: Define sampling distributions (normal, chi-square, Students t and F) and solve elementary numerical problems.
CO.6: Practicals: Use built in functions of R to solve numerical problems on modules I, II & IV.

Module Outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1	MO 1.1	Explain discrete standard distributions and their practical applications.	Understand
	MO 1.2	Describe the theoretical properties of these distributions.	Understand
	MO 1.3	Solve numerical problems associated with these distributions.	Apply
	MO 1.4	Fit binomial and Poisson distributions to data sets and calculate theoretical frequencies.	Analyze
MODULE	MO 2.1	Define continuous standard distributions.	Understand

2	MO 2.2	Describe the theoretical properties of these distributions.	Understand
	MO 2.3	Solve numerical problems associated with these distributions.	Apply
	MO 2.4	Fit Normal distribution to data sets and calculate theoretical frequencies.	Analyze
MODULE 3	MO 3.1	Explain Chebycheff's inequality and laws of large numbers.	Understand
	MO 3.2	Derive Chebycheff's inequality and laws of large numbers.	Apply
	MO 3.3	Apply the laws of large numbers to solve numerical problems.	Analyze
MODULE 4	MO 4.1	Distinguish between parameter and statistic.	Understand
	MO 4.2	Define sampling distributions (normal, chi-square, t and F).	Remember
	MO 4.3	Derive distributions of sample mean and sample variance.	Understand
	MO 4.4	Solve numerical problems associated with these distributions using their respective table values.	Apply
	MO 4.5	State relations between the sampling distributions.	Remember
MODULE 5 (only for Practical Exam)	MO 5.1	Use built-in R functions to solve numerical problems associated with standard distributions and sampling distributions. (to the extent of the portions covered in the modules I, II and IV)	Apply

Course Content

Module I:
Standard Distributions (Discrete)- uniform, binomial, Poisson and geometric- moments, moment generating function, characteristic function, problems, additive property (binomial and Poisson), recurrence relation (binomial and Poisson), Poisson as a limiting form of binomial, memoryless property of geometric distribution; Fitting of binomial and Poisson distributions; hypergeometric distribution (definition, mean and variance only).

Module II:
Standard Distributions (Continuous)– uniform, exponential, and gamma - moment generating function, characteristic function, problems; memoryless property of exponential distribution; additive property of gamma distribution; beta distribution (I and II kinds)- moments, normal distribution- moments, moment generating function, characteristic function, problems, recurrence relation of central moments; convergence of binomial and Poisson to normal.

Module III:
Chebychev's inequality; Law of large numbers-BLLN, convergence in probability (definition only), WLLN; central limit theorem (Lindberg-Levy form) - statement and applications only.

Module IV:
Sampling distributions - Parameter and statistic, Sampling distributions- Distribution of mean of a sample taken from a normal population, chi-square - definition and properties, t and F distributions (definitions only) and statistics following these distributions, relation between normal, chi-square, t and F distributions.

Module V:
Numeric problems based on Modules I, II & IV – Discrete and continuous probability distributions and evaluation of probabilities, sampling distributions and their probability evaluation, random number generation.

References

1. Gupta S.C. and Kapoor V.K. (1980). *Fundamentals of Mathematical Statistics*. Sultan Chand and Sons, New Delhi.
2. John E. Freund (1980*). Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*. New Age International (P) Ltd, New Delhi.
4. Mukhopadhyay, P. (1996). *Mathematical Statistics*. New Central Book Agency (P) Ltd, Calcutta.
5. Rohatgi V. K. (1993). *An Introduction to Probability Theory & Mathematical Statistics.* Wiley Eastern, New Delhi.

Semester – IV

Course - IV

ST 1431.1: Statistical Inference

Credits: 3

Hours/week: 5 (L-3, P-2)

Course outcomes

On completion of the course, the students should be able to:

CO.1: Analyze a sample to draw valid inferences about the parameters of a statistical population.
CO.2: Explain the properties of estimators and solve numerical problems for the point and interval estimators of the parameters.
CO.3: Explain the concept of testing statistical hypotheses.
CO.4: Identify two types of errors, compute level of significance and power of a test.
CO.5: Conduct tests for hypothesis about the population mean and proportion using large samples.

CO.6: Conduct tests for hypothesis about the homogeneity and independence using chi-square statistics.

CO.7: Conduct tests for hypothesis about the mean and variance for normal population using small samples.

CO.8: Carry out and interpret ANOVA.

CO.9: Practical: Use R built-in functions to solve numerical problems associated with topics covered in various modules.

Module outcomes

Sl. No:	Outcomes		Taxonomy Level
	On completion of each module, students should be able to:		
MODULE 1	MO 1.1	Define point estimator of a parameter in a statistical population.	Remember
	MO 1.2	Illustrate whether an estimator satisfying unbiased and consistent.	Understand
	MO 1.3	Explain sufficiency and efficiency of an estimator.	Apply
	MO 1.4	Describe maximum likelihood estimator and moment estimator of a parameter.	Apply
	MO 1.5	Define confidence interval.	Remember
	MO 1.6	Construct confidence intervals for mean, variance and proportion in a population.	Apply
MODULE 2	MO 2.1	Explain the concept of statistical hypothesis.	Understand
	MO 2.2	Describe two types of errors in a statistical hypothesis.	Understand
	MO 2.3	Determine the level of significance and power of a test.	Apply
	MO 2.4	Explain Neyman- Pearson lemma.	Apply
MODULE 3	MO 3.1	Define large sample and small sample tests.	Remember
	MO 3.2	Describe the test procedure for mean and proportion (one and two sample cases) using large samples.	Apply
	MO 3.3	Examine the homogeneity and independence using chi-square tests	Apply
	MO 3.4	Explain paired t test.	Apply
	MO 3.5	Describe the test procedure for mean and variance (one and two sample cases) for normal population using small samples.	Apply
MODULE 4	MO 4.1	Explain the concept of Analysis of variance.	Understand
	MO 4.2	Explain the model and hypothesis of one way and two way classified data.	Understand
	MO 4.3	Construct ANOVA table and draw inferences from it.	Evaluate
MODULE 5 (only for Practical Exam)	MO 5.1	Use built-in R functions to solve numerical problems associated with Modules III & IV.	Apply

Course content

Module I:
Point estimation, desirable properties of estimators – unbiasedness, consistency, efficiency and sufficiency; Methods of estimation –Maximum likelihood method and method of moments; Interval estimation of mean, variance and proportion (single unknown parameter only).

Module II:
Testing of Hypothesis: statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p-value, power of a test, Neyman-Pearson lemma (statement only) and applications.

Module III:
Large sample tests – testing mean and proportion (one and two sample cases), chi-square test of goodness of fit, independence and homogeneity.
Small sample tests- Z-test for means; one sample test for mean of a normal population, equality of means of two independent normal populations, t-test for independent samples and paired samples, chi-square test for variance, F-test for equality of variances.

Module IV:
Design of Experiments- assumptions and principles, Analysis of Variance (ANOVA) of one way and two way classified data (Derivation of two– way model is not included).

Module V: Practical based on Modules III &IV – tests of hypotheses (as given in Practical Sheet – 11); one way and two way ANOVA.

References

1. Das M. N., Giri N. C. (2003). *Design and analysis of experiments*. New Age International (P) Ltd, New Delhi.
2. John E. Freund (1980). *Mathematical Statistics*. Prentice Hall of India, New Delhi.
3. Medhi J. (2005). *Statistical Methods-An Introductory Text*, New Age International (P) Ltd. New Delhi.
4. Paul G. Hoel, Sidney C. Port, Charles J. Stone (1971). *Introduction to Statistical Theory*. Universal Book stall, New Delhi.

Semester – IV

Course - V

ST 1432.1: Practical using R

Credits: 4

Any standard version of R in any operating system can be used. The Record book is mandatory to appear for the Practical examination. The Record book should contain following Practical sheets based on Module V of Courses ST1131.1 to ST 1431.1. Minimum number of questions covering all functions/methods given therein must be included in each practical sheet along with R code, their outputs, interpretation / conclusion.

Practical Sheet - 1: Data Types in R

Basics of vector, matrix and data frame, basic functions – c( ), sequence( ), scan( ), factor( ) table( ), and cut( ).

Minimum number of questions - 12

Practical Sheet - 2: Sampling and Frequency Tables.

Forming ungrouped and grouped frequency tables with raw data using table and cut functions. SRSWR and SRSWOR with sample( )

Minimum number of questions - 8

Practical Sheet - 3: Measures of Central Tendency

Descriptive measures: sum, sort, min, max, length, mean, median, mode (using sort and table), geometric mean, harmonic mean.

Minimum number of questions - 10

Practical Sheet - 4: Measures of Dispersion

Range, mean deviation, IQR, quartile deviation, sd, var, coefficient of variation, quantile, summary.

Minimum number of questions - 10

Practical Sheet - 5: Moments, Skewness and Kurtosis

Computation of raw, central moments, moment measures of skewness and kurtosis.

Minimum number of questions - 8

Practical Sheet - 6: Graphical Methods

Simple bar plot, multiple bar plot (side by side and subdivided), pie chart, histogram, scatter plot, plot function and lines function.

Minimum number of questions - 8

Practical Sheet - 7: Probability Distributions

Binomial, Poisson, normal, chi-square, t and F distributions – The **d**, **p, q** and **r** functions, the scale function, evaluation of probabilities using these functions.

Minimum number of questions - 10

Practical Sheet - 8: Fitting of Distributions

Fitting of binomial, Poisson and normal distributions.

Minimum number of questions - 3

Practical Sheet - 9: Correlation and Regression

Computation of covariance for a bivariate data using cov(), Pearson's and Spearman's correlation coefficient using cor(). Linear regression models: fitting using lm(), prediction from fitted model.

Minimum number of questions - 6

Practical Sheet - 10: Curve Fitting

Fitting of a straight line and $y = ax^2 + bx + c, a \neq 0$; $y = ae^{bx}, y = ab^x$ and $y = ax^b$, where $a, b \text{ and } c$ are real constants.

Minimum number of questions - 5

Practical Sheet - 11: Testing of Hypotheses

Testing of hypothesis: prop.test (one sample and two sample), t.test (one sample, two sample, and paired), chi squared tests (goodness of fit, and independence of attributes). F test for equality of variances.

Minimum number of questions - 8

Practical Sheet - 12: Analysis of Variance

Analysis of Variance: One way anova and two way anova with one observation per cell.

Minimum number of questions - 4

References:

1. Dalgaard, P.(2008). *Introductory Statistics with R*, Springer, New York.
2. Kerns, G J. (2010). *Introduction to Probability and Statistics using R.* ISBN-10 : 0557249791
3. Lander J. P. (2017). *R for everyone* 2/e. Addison-Wesley Professional, U. S.
4. Michael J. Crawley (2013*). The R Book*, 2/e, Wiley, New York.
5. Purohit, S. G., Deshmukh, S.R., & Gore, S. D. (2008). *Statistics using R.* Alpha Science International, United Kingdom.

Web Resources:

1. https://cran.r-project.org
2. https://cran.r-project.org/manuals.html
3. https://www.r-project.org/other-docs.html
4. https://journal.r-project.org/
5. https://www.r-bloggers.com

UNIVERSITY OF KERALA
First Degree Programme under CBCSS
Scheme and Syllabus (Outcome Based Education) of Complementary STATISTICS for B. Sc. Physics Core
(with effect from 2022 Admission)

The goal of the syllabus is that students understand statistics by using it effectively in real life situations. It is aimed that students have experience of the application of statistical methods to analyze data and get acquainted with situations where statistical thinking is helpful. Emphasis is given to practical-data collection and use of appropriate statistical tools to analyze them. The syllabus is prepared according to the Outcome Based Education (OBE) paradigm. There has to be lectures supported by problem sheets. There are practical sessions associated with each semester. Statistical computation with R is introduced which would help the students for analyzing data by making optimum usage of time and resources. For practical classes, there shall be one faculty member in charge of every 16 students (based on sanctioned strength), in accordance with the University regulations. Numerical problem solving using scientific calculators is also included in the End Semester Examination (ESE) of Courses I, II, III & IV. There is a course in practical using R in Semester IV.

ESE of Courses I, II, III, & IV will be of 3 hours duration and have questions from all modules. Courses I & II will be of 2 credits each, III & IV will be of 3 credits each. The ESE of practical course in semester IV will be of 2 hours duration and of credit 4. Students are required to produce a duly certified bona fide Record of practical work done (Module VI of courses in semesters I, II, III and IV) using R software, which is mandatory to appear for the practical examination. Complementary Course V will be computer based, and its ESE for 60 marks will be held under the supervision of external examiners duly appointed by the University, who will also evaluate Record of practical work done for 20 marks.

Course Structure:

Sem	Title of the Course	Hrs/Week		No. of Credits	Total Hrs/Sem	ESE duration	Evaluation weightage	
		L	P				CE	ESE
I	ST1131.2 Descriptive Statistics	2	2	2	72	3 hrs	20%	80%
II	ST1231.2 Probability Theory	2	2	2	72	3 hrs	20%	80%
III	ST1331.2 Probability Distributions and Stochastic Processes	3	2	3	90	3 hrs	20%	80%
IV	ST 1431.2 Statistical Inference	3	2	3	90	3 hrs	20%	80%
	ST 1432.2 Practical using R			4		2 hrs	20%	80%

L- Lecture hours; P-Practical (Lab) hours

Semester: I
Course: I
ST 1131.2: Descriptive Statistics
Credits: 2; Hours/week – 4 (L-2, P-2)

Course outcomes

On completion of the course, students should be able to:

CO.1: Explain the various methods of collection of primary and secondary data, explain the concepts of statistical survey, present raw data using frequency tables.

CO.2: Explain the various methods of collection of primary and secondary data, explain the concepts of statistical survey, present raw data using frequency tables.

CO.3: Summarise data using various measures of skewness and kurtosis.

CO.4: Explain the concept of principle of Least squares, fit various curves to the given data sets and explain the concepts of scatter diagram.

CO.5: Explain the concept of correlation and calculate correlation between two variables.

CO.6: Explain the concept of Regression, Fit various regression equations to given data sets and identification of regression lines.

CO.7: Practical: Use R built in functions to solve numerical problems associated with topics covered in modules I and II.

Module outcomes

Module	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module I	MO 1.1 Define primary and secondary data. MO 1.2 Distinguish between classification and tabulation. MO 1.3 Explain various methods of collecting primary data. MO 1.4 Construct various frequency tables.	Remember Apply Understand Create
Module II	MO 2.1 Calculate various measures of central tendency and dispersion. MO 2.2 Compare the merits and demerits of different measures of central tendency and dispersion. MO 2.3 Compare various data sets based on measures of central tendency and dispersion.	Apply Analyze Evaluate
Module III	MO 3.1 Describe certain theoretical properties of moments MO 3.2 Compare various data sets based on skewness and kurtosis.	Understand Evaluate
Module IV	MO 4.1 Apply the principle of Least Squares to fit various curves.	Apply

	MO 4.2 Explain the concept of scatter diagram. MO 4.3 Fit various curves to data sets.	Understand Apply
Module V	MO 5.1 Calculate Karl Pearson's Coefficient of Correlation and Spearman's Rank correlation coefficient and interpret the results MO 5.2 Construct regression lines for data sets. MO 5.3 Identify regression lines MO 5.4 Calculate the angle between regression lines, point of intersection.	Evaluate Apply Analyze Apply
Module VI (only for Practical exam)	MO 6.1 Use built in R functions to draw diagrams and graphs, calculate various measures of descriptive statistics	Apply

COURSE CONTENT

Module I: Concept of primary and secondary data, organization of a statistical survey, methods of collection of primary and secondary data, classification and tabulation of data, histogram, frequency curve, frequency polygon and ogive.

Module II: Central tendency and its measures-mean, median, mode, geometric mean, harmonic mean and combined mean. Dispersion and its measures- range, quartile deviation, mean deviation, standard deviation, Coefficient of variation and its use. Numerical problems covering these topics**.**

Module III: Raw moments, central moments and their inter-relationship, Sheppard's correction for moments for grouped data, skewness and its measures based on quartiles and moments, kurtosis and its moment measure. Numerical problems covering these topics.

Module IV: Concept of bivariate data, scatter diagram, curve fitting, principle of least squares. Fitting of curves of the forms: $y=ax + b$, $y = ax^2 + bx + c$, $y=ae^{bx}$, $y = ab^x$ and $y = ax^b$. Numerical problems covering these topics.

Module V: Linear correlation, Karl Pearson's coefficient of correlation, its invariance property, Spearman's rank correlation coefficient, tied ranks. Regression lines, its relation with correlation coefficient. Identifying regression lines, angle between regression lines.Numerical problems covering these topics.

Module VI: Basics of R (as given in Practical Sheet - 1); Practical based on modules I, II using R (for practical examination only).

References

1. Elhance, D. N., Elhance, V. & Agarwal, B. M. Fundamentals of Statistics, Kitab Mahal Publications, Delhi.
2. Goon, A. M., Gupta, M. K. & Dasgupta, B. Fundamentals of Statistics. The World Press
3. Gupta, S. C. & Kapoor, V. K. Fundamentals of Mathematical Statistics, Sultan Chand, New Delhi.
4. Martin B. R. Statistics for Physicists, Academic Press, London.

5. Mathai, M. & Rathie, P. N. Probability and Statistics. McMillan.
6. Purohit, G.S., Gore, S.D., Deshmukh, S. R. Statistics using R, Alpha Science Intl.

Semester: II
Course: II
ST 1231.2: Probability Theory

Credits: 2; Hours /week – 4 (L-2, P-2)

Course outcomes

On completion of the course, students should be able to:

CO.1: Explain the different concepts of probability, Definition of random and non-random experiments, sample space, events etc.

CO.2: Explain Conditional Probability and check the Independence of events.

CO.3: Explain Bayes' Theorem and its applications.

CO.4: Distinguish between discrete and continuous random variables and concept of transformation of random variables in simple one - one functions.

CO.5: Explain bivariate distribution and concept of marginal and conditional distributions.

CO.6: Explain the concept of expectation, m.g.f and characteristic functions.

CO.7: Determination of conditional mean and conditional variance.

CO.8: Practical: Use R built in functions to solve numerical problems associated with topics covered in Modules III to V of ST 1131.2 (in Sem 1).

Module Outcomes

Module	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module I	MO 1.1 Distinguish between random and non-random experiments. MO 1.2 Describe different approaches of probability. MO 1.3 Explain the concept of sample space and types of events.	Remember Understand Understand
Module II	MO 2.1 Determine conditional probability MO 2.2 Explain the concept of independence of events. MO 2.3. Apply Bayes' theorem and find out the posterior probability.	Apply Understand Apply
Module III	MO 3.1 Explain the concept of random variable. MO 3.2 Distinguish between discrete and continuous random variables. MO 3.3 Apply the concept of transformation of univariate random variables one – one functions.	Understand Understand Analyze
Module IV	MO 4.1 Explain the concept of bivariate distributions. MO 4.2 Evaluate marginal and conditional distributions of bivariate random variables. MO 4.3 Check for independence of random variables.	Understand Evaluate Apply
Module V	MO 5.1 Explain the concept of expectation and its	Understand

	properties. MO 5.2 Calculate the expectation of discrete and continuous random variables. MO 5.3 Explain the concept of m.g.f and characteristic function. MO 5.4 Define conditional mean and conditional variance. MO 5.5 Determine conditional mean and conditional variance of bivariate distributions.	 Apply Understand Remember Apply
Module VI (only for Practical exam)	MO 6.1 Use built in R functions to: Evaluate of problems in Modules III to V in ST 1131.2 in Semester 1	Apply

COURSE CONTENT

Module I: Basic concepts**:** deterministic and random experiment, sample space, events, equally likely mutually exclusive and exhaustive events. Definition of probability- mathematical, statistical and axiomatic. Definition of probability measure. Addition theorem (limited to 3 events.) Numerical problems on these topics.

Module II: Conditional Probability and Independence of events. Pair wise and mutual independence, multiplication theorem (limited to 3 events) , Bayes' theorem and numerical problems on these topics.

Module III: Definition of random variable, discrete and continuous random variables. Probability mass function, Probability density function, distribution function, functions of random variables, change of variables (simple 1-1 functions only) and problems on these topics.

Module IV: Bivariate distribution (discrete and continuous), joint, marginal, and conditional distributions, independence of two random variables and problem on these topics.

Module V: Mathematical expectation, Definition and elementary properties, M.D from mean, moments, m.g.f and its properties, characteristic function and its properties, Definition and simple properties of conditional mean and conditional variance and problems on these topics.

Module VI: Practical using R based on modules III, IV and V of ST 1131.2 of Semester 1 (for practical examination only).

References

1. Gun, A. M., Gupta, M. K. & Dasgupta, B. Fundamentals of Statistics. The World Press.
2. Gupta, S. C. & Kapoor, V. K. Fundamentals of Mathematical Statistics, Sultan Chand, New Delhi.
3. Martin B. R. Statistics for Physicists, Academic Press, London.
4. Mathai, M. & Rathie, P. N. Probability and Statistics. MacMillan.
5. Purohit, G.S., Gore, S.D., Deshmukh, S. R. Statistics using R, Alpha Science Intl.

Semester: III
Course: III
ST 1331.2 Probability Distributions and Stochastic Processes

Credits: 3; Hours/week – 5 (L-3, P-2)

Course outcomes:

On completion of the course, students should be able to:

CO.1: Describe the characteristics of different discrete and continuous distributions.

CO.2: Solve numerical problems related to statistical distributions.

CO.3: Explain the concepts of statistic, parameter and sampling distributions.

CO.4: Solve numerical problems related to sampling distributions.

CO.5: Describe the concept of combinatorial analysis.

CO.6: Explain concepts such as stochastic processes, Markov chains, transition probability matrix, various types of states and random walk.

CO.7: Determination of conditional mean and conditional variance.

CO.8: Practical: Use R built in functions to solve numerical problems associated with topics covered in modules I to III

Module outcomes

Module	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module I	MO 1.1 Describe various discrete distributions. MO 1.2 Describe the theoretical properties of various standard discrete distributions. MO 1.3 Solve numerical problems based on these distributions. MO 1.4 Fitting of Binomial and Poisson distribution to data sets.	Understand Understand Apply Analyze
Module II	MO 2.1 Describe various standard continuous distributions. MO 2.2 Describe the theoretical properties of these continuous distributions. MO 2.3. Solve various problems related these continuous distributions. MO 2.4 Fitting of Normal distribution to data sets.	Understand Understand Apply Analyze
Module III	MO 3.1 Articulate concepts of statistic and parameter. MO 3.2 Define sampling distribution normal, Chi-square, t and F distribution. MO 3.3 Describe various statistic following these distributions and their interrelation.	Understand Remember Understand

	MO 3.4 Solve numerical problems associated with these sampling distributions.	Apply
Module IV	MO 4.1 Explain the concepts of combinatorial analysis. MO 4.2 Distinguish and differentiate different statistics such as Maxwell-Boltzmann statistic, Bose-Einstein statistic and Fermi-Dirac statistic.	Understand Understand
Module V	MO 5.1 Describe the concept of Stochastic Processes, classification of states. MO 5.2 Define Markov chain, transition probabilities, random walk and Brownian motion. MO 5.3 Distinguish between various processes such as Markov, Poisson process based on their properties.	Understand Remember Understand
Module VI (only for Practical exam)	MO 6.1 Use built in R functions to solve numerical problems associated with standard distributions and sampling distributions (to the extent of the portions covered in the modules I, II and III).	Apply

COURSE CONTENT

Module I: Standard Discrete Distributions: uniform, binomial, Poisson and geometric distributions and their properties. Fitting of binomial and Poisson distribution.

Module II: Standard Continuous Distributions: rectangular, beta, gamma, exponential, normal, Weibull distributions and their properties. Fitting of normal distribution.

Module III: Concept of random sample, statistic, parameter, standard error, sampling distribution. Sampling distribution of mean of samples taken from a normal population, sampling distribution of variance of samples taken from a normal population. Chi-square, Student's t and F distribution (derivation of pdf not required), their inter-relationship, examples of statistics following these distributions. Central limit theorem (statement only).

Module IV: Elements of Combinatorial Analysis: Definition of pairs and multiplets, ordered samples, subpopulation and partitions, Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistic.

Module V: Stochastic Processes: Introduction, time and state space, classification of stochastic processes, process with stationary independent increments (definition only). Basic concepts and examples of Markov Process, Markov chain, transition probability matrix, initial probability vector. Definitions of random walk and Brownian motion.

Module VI: Practical based on modules I, II and III using R (for practical examination only).

References

1. Biswal, P.C. Probability and Statistics. Prentice Hall of India.
2. Feller,W. An Introduction to Probability Theory and its Applications. Chapter - 2,Volume 1., Wiley Eastern Limited (New Delhi).
3. Gupta, S. C. and Kapoor, V.K. Fundamentals of Mathematical Statistics. Sultan Chand and Co. New Delhi.

4. Kerns G. J. (2011). Introduction to Probability and Statistics using R, Springer.
5. Mathai, A.M. and Rathe, P.N. Probability and Statistics. Macmillan Company of India. NewDelhi.
6. Nabendu Pal and Sahadeb Sarkar. Statistics Concepts and Applications. Prentice Hall of India.
7. Nabendu Pal and Sahadeb Sarkar. Statistics Concepts and Applications. Prentice Hall of India.
8. Purohit, G.S., Gore, S.D., Deshmukh, S. R. (2008). Statistics using R, Alpha Science Intl.

Semester: IV
Course: IV
ST 1431.2 Estimation Theory and Testing of Hypothesis

Credits: 3; Hours/week – 5 (L-3, P-2)

Course outcomes

On completion of the course, students should be able to:

CO.1: Explain the concept of point estimation, desirable properties of good estimator and different methods of estimation.

CO.2: Obtain point estimators for the parameters.

CO.3: Describe the concept of interval estimation and to solve problems related to interval estimation.

CO.4: Describe the concept of hypotheses testing and different testing procedure.

CO.5: Solve numerical problems related to testing.

CO.6: Explain the concept of ANOVA and to solve numerical problems.

CO.7: Determination of conditional mean and conditional variance.

CO.8: Practical: Use R built in functions to solve numerical problems associated with topics covered in modules III to V

Module outcomes

Module	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module I	MO 1.1 Explain the concept of estimation theory. MO 1.2 Obtain different estimators. MO 1.3 Solve numerical problems and obtain point estimate related to a given data set.	Understand Apply Apply
Module II	MO 2.1 Articulate concepts of interval estimation. MO 2.2 Obtain interval estimator of parameters. MO 2.3 Solve numerical problems related to interval estimation.	Understand Apply Apply
Module III	MO 3.1 Define the concept of hypothesis testing. MO 3.2 Obtain test statistic and carry out testing procedures such as normal test, Chi square test of	Understand Apply

	goodness of fit and testing independence of attributes. MO 3.3 Solve various problems associated with normal test and Chi-square test.	 Analyze
Module IV	MO 4.1 Describe various small sample tests such as tests for population mean(s), variance, paired t test and F test. MO 4.2 Obtain test statistic and carry out testing procedures. MO 4.3 Solve numerical problems related to small sample tests.	Understand Apply Analyze
Module V	MO 5.1 Explain the concept of Analysis of variance - One way and two way classifications. MO 5.2 Carry out tests based on Analysis of variance – One way and two way classifications. MO 5.3 Solve numerical problems associated with ANOVA	Understand Apply Analyze
Module VI (only for Practical exam)	MO 6.1 Use built in R functions to solve numerical problems associated with modules III to V.	Apply

COURSE CONTENT

Module I: Point Estimation-Concept, Desirable properties of a good estimator. Fisher – Neyman Factorization theorem and applications. Methods of Estimation–Maximum likelihood estimation and moment method of estimation.

Module II: Interval Estimation-Concept, Interval estimation of mean, variance and proportion, interval estimation of differences of means.

Module III: Basic concepts of testing hypotheses, Statement of Neyman–Pearson lemma and its use, Large sample tests concerning mean, equality of means, proportion and equality of proportions. Test based on Chi-square distribution for testing goodness of fit and independence of attributes.

Module IV: Small sample tests: Testing the hypotheses of mean and equality of means for normal population, paired t-test, testing the hypotheses of variance and equality of variance for normal population.

Module V: One-way and Two-way Analysis of Variance (with one observation per cell): assumptions, data layout, model specification, hypothesis and various sum of squares (without any derivation). ANOVA table and conclusions. Numerical problems.

Module VI: Practical based on modules II - V using R (for practical examination only).

References

1. Biswal P.C. Probability and Statistics. Prentice Hall of India.
2. Gupta, S. C. and Kapoor, V.K. Fundamentals of Mathematical Statistics. Sultan Chand and Co. New Delhi.

3. Gupta, S. C. and Kapoor, V.K. Applied Statistics. Sultan Chand and Co. New Delhi.
4. Kerns G. J. Introduction to Probability and Statistics using R, Springer.
5. Mathai A.M and Rathe P.N. Probability and Statistics. Macmillan Company of India. NewDelhi.
6. Nabendu Pal and Sahadeb Sarkar. Statistics Concepts and Applications. Prentice Hall of India.
7. Purohit, G.S., Gore, S.D., Deshmukh, S. R. Statistics using R, Alpha Science Intl.

Semester: IV
Course: V
ST 1432.2 Practical using R

Credits: 4

Any standard version of R in any operating system can be used. The Record book is mandatory to appear for the Practical examination and the Record book should contain following Practical sheets based on Module VI of Courses ST1131.2 to ST 1431.2. Minimum number of questions covering all functions/methods given therein must be included in each practical sheet along with their R code, outputs, interpretations / conclusions.

Practical Sheet - 1: Data Types in R

Basics of vector, matrix and data frame, basic functions – c( ), sequence( ), scan( ), factor( ), table( ), and cut( ).

Minimum number of questions - 12

Practical Sheet - 2: Frequency Tables.

Forming ungrouped and grouped frequency tables with raw data using table and cut functions.

Minimum number of questions - 4

Practical Sheet - 3: Measures of Central Tendency

Descriptive measures: sum, sort, min, max, length, mean, median, mode (using sort and table), geometric mean, harmonic mean.

Minimum number of questions - 10

Practical Sheet - 4: Measures of Dispersion

Range, mean deviation, IQR, quartile deviation, sd, var, coefficient of variation, quantile, summary.

Minimum number of questions - 10

Practical Sheet - 5: Moments, Skewness and Kurtosis

Computation of raw, central moments, moment measures of skewness and kurtosis.

Minimum number of questions - 8

Practical Sheet - 6: Graphical Methods

Simple bar plot, multiple bar plot (side by side and subdivided), pie chart, histogram, scatter plot, plot function and lines function.

Minimum number of questions - 8

Practical Sheet - 7: Correlation and Regression

Computation of covariance for a bivariate data using cov(), Pearson's and Spearman's correlation coefficient using cor(). Linear regression models: fitting using lm(), prediction from fitted model.

Minimum number of questions - 6

Practical Sheet - 8: Curve Fitting

Fitting of a straight line and $y = ax^2 + bx + c, a \neq 0$; $y = ae^{bx}, y = ab^x$ and $y = ax^b$, where a, b *and* c are real constants.

Minimum number of questions – 5

Practical Sheet - 9: Probability Distributions

Binomial, Poisson, normal, chi-square, t and F distributions – The **d**, **p, q** and **r** functions, the scale function, evaluation of probabilities using these functions.

Minimum number of questions - 10

Practical Sheet - 10: Fitting of Distributions

Fitting of binomial, Poisson and normal distributions.

Minimum number of questions - 3

Practical Sheet - 11: Testing of Hypotheses

Testing of hypothesis: prop.test (one sample and two sample), t.test (one sample, two sample, and paired), chi squared tests (goodness of fit, and independence of attributes). F test for equality of variances.

Minimum number of questions - 8

Practical Sheet - 12: Analysis of Variance

Analysis of Variance: One way anova and two way anova with one observation per cell.

Minimum number of questions – 4

References:

1. Dalgaard, P.(2008). *Introductory Statistics with R*, Springer, New York.

2. Kerns, G J. (2010). *Introduction to Probability and Statistics using R.* ISBN-10 : 0557249791
3. Lander J. P. (2017). *R for everyone* 2/e. Addison-Wesley Professional, U. S.
4. Michael J. Crawley (2013*). The R Book*, 2/e, Wiley, New York.
5. Purohit, S. G., Deshmukh, S.R., & Gore, S. D. (2008). *Statistics using R*. Alpha Science International, United Kingdom.

Web Resources:

1. https://cran.r-project.org
2. https://cran.r-project.org/manuals.html
3. https://www.r-project.org/other-docs.html
4. https://journal.r-project.org/
5. https://www.r-bloggers.com

UNIVERSITY OF KERALA
First Degree Programme under CBCSS
Scheme and Syllabus (Outcome Based Education) of Complementary STATISTICS for B. Sc. GEOGRAPHY Core
(w.e.f. 2022 Admission)

The main objective of the syllabus is to equip students with the concepts, theories, principles and methods of Statistics. The syllabus is prepared in accordance with the paradigm conceived in Outcome Based Education (OBE). The course envisages not only the students be familiarized with the applications of statistical theories to identify the suitable probability models in real life situation but also acquaint them to carry out statistical inference problems using R software. Practical sessions are included in each semester of the course. For practical classes, there shall be one faculty member in charge of every 16 students (based on sanctioned strength), in accordance with the University regulations. Solution of statistical problems requiring numerical computation using scientific calculator and statistical table are included in the End Semester Examination (ESE) of Courses in the semesters I, II, III & IV. One course in practical using R software is included in Semester IV. ESE of theory courses in semesters I, II, III, & IV will be of 3 hours duration. Courses in semesters I & II will be of 2 credits each and in semesters III & IV, 3 credits each. The practical examination in semester IV will be of 2 hours duration, with a credit of 4. It is mandatory to submit a duly certified bona fide practical record consisting of print-out of complete analysis of numerical problems done using R software. ESE of 60 marks for Practical Course will be held under the supervision of external examiner duly appointed by the University, who will also evaluate practical record for 20 marks.

Course Structure:

Semester	Title of the Course	Hrs/Week		No.of Credits	Total Hrs/Week	ESE duration	Weightage in %	
		L	P				CE	ESE
I	ST1131.3 Descriptive Statistics	2	2	2	72	3 hrs	20	80
II	ST1231.3 Sampling and Probability Distributions	2	2	2	72	3 hrs	20	80
III	ST1331.3 Statistical Inference	3	2	3	90	3 hrs	20	80

IV	ST 1431.3 Statistical Techniques for Geography	3	2	3	90	3 hrs	20	80
	ST 1432.3 Practical using R			4		2 hrs	20	80

L – Lecture hour; P – Practical hour

Semester I
Course - I
ST 1131.3 Descriptive Statistics

Course outcomes

On completion of the course, the students should be able to:

CO.1: Explain the need of Statistics in scientific studies.
CO.2: Describe the difference between qualitative and quantitative variables and classify measurements based on their scale.
CO.3: Apply different techniques of classification of data.
CO.4: Apply various diagrammatic and graphical tools to represent a data.
CO.5: Calculate various measures of central tendency and dispersion.
CO.6: Compute and interpret the skewness and kurtosis of a data set.
CO.7: Apply curve fitting methods to identify the relationship between variables.
CO.8: Calculate and interpret the values of correlation coefficients of bivariate data sets.
CO.9: Practical: Basics of R. Use R functions to solve numerical problems in Modules I and II

Module outcomes

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE I	MO1.1 Explain the need of Statistics in scientific studies. MO 1.2 Describe the difference between the qualitative and quantitative variables. MO 1.3 Classify data according to nominal, ordinal, interval and ratio scales. MO 1.4 Apply different techniques of classification of data. MO 1.5 Apply various diagrammatic and graphical tools to represent a data.	Understand Understand Understand Apply Apply
MODULE II	MO 2.1 Define central tendency. MO 2.2 Define mean, median and mode. MO 2.3. Compute mean, median and mode for different types of data.	Remember Remember Apply
MODULE III	MO 3.1 Explain dispersion. MO 3.2 Define various measures of dispersion. MO 3.3 Calculate various measures of dispersion for data sets. MO 3.4 Calculate and interpret the value of coefficient of variation of a data set.	Understand Remember Apply Apply
MODULE IV	MO4.1 Define raw and central moments.	Understand

	MO4.2 State the relationship between raw and central moments. MO4.3 Describe the concept of skewness and kurtosis. MO4.4Compute raw moments and central moments of data sets. MO4.5Calculate and interpret the measures of skewness and kurtosis.	Understand Understand Apply Apply
MODULE V	MO 5.1 Describe the concept of principle of least squares. MO 5.2 Apply principle of least squares to fit straight line, parabola and the exponential curve $Y=Ae^{BX}$. MO 5.3 Explain the use of scatter diagram. MO 5.4 Describe the concept of correlation. MO 5.5 Calculate and interpret values of Karl Pearson correlation coefficient and Spearman's rank correlation coefficient. MO 5.6 Describe the concept of regression and fitting	Understand Apply Understand Understand Apply Apply
Module VI (only for practical exam)	MO 6.1 Use built in R functions to: construct charts and diagrams; upto computation of measures of central tendency.	Apply

Course Content

Module I: Basic concepts: Need of Statistics in scientific studies, constants and variables, qualitative and quantitative variables, data- scales of measurements (nominal, ordinal, interval and ratio), classification of data, diagrammatic and graphical representation of data.

Module II: Measures of central tendency - arithmetic mean, median and mode (concepts and problems only, mathematical derivation is not required).

Module III: Measures of dispersion - range, quartile deviation, mean deviation, variance, standard deviation, coefficient of variation and its significance (concepts and problems of only, mathematical derivation not required).

Module IV: Skewness and kurtosis, raw and central moments (definitions and relationships without proof), Karl Pearson's, Bowley's and moment measures of skewness, moment measure of kurtosis.

Module V: Bivariate data: Relationship of variables, curve fitting- principle of least squares, fitting of straight line, parabola and exponential curve of the form $Y=Ae^{BX}$, scatter diagram, Correlation- Karl Pearson's correlation coefficient and Spearmen's rank correlation coefficient, regression, regression lines (concepts and problems, mathematical derivation not required)

Module VI: For practical examination only: Basics of R, Construction of charts and diagrams, calculation of measures of central tendency (Practical Sheets 1 to 4)

Semester II

Course - II

ST 1231.3 Sampling and Probability Distributions

Course Outcomes

On completion of the course, the students should be able to:

CO 1: Explain the concepts of data collection, primary data, secondary data, sampling frame and various sampling methods like simple random sampling, systematic and stratified sampling.

CO 2: Classify the outcomes of a random experiment and identify equally likely events, mutually exclusive events and exhaustive events.

CO3: Explain the concepts of probability through classical and frequency approaches and axioms of probability.

CO4: Describe the concepts of conditional probability, multiplication theorem, independence, Bayes theorem and to compute posteriori probability using Bayes theorem.

CO 5: Explain the concept of random variable, discrete and continuous types, probability distributions, distribution function and mathematical expectation.

CO6: Discuss probability distribution and expectation of random variables.

CO 7: Describe the practical situations in which binomial, Poisson and normal distributions are applied.

CO 8: Describe elementary properties of binomial, Poisson and normal random variables.

CO 9: Practicals based on R software: Computation of measures of dispersion, correlation and regression and curve fitting.

Module Outcomes

Sl.No	Outcomes	Taxonomy Level
Module I	MO 1.1: Explain the concepts data collection, primary data and secondary data	Understand
	MO 1.2: Describe the difference between sampling units and sampling frame	Understand
	MO 1.3: Definition and examples of probability sampling and non- probability sampling.	Understand
	MO 1.4: Explain various sampling methods like simple random sampling, stratified sampling and systematic sampling.	Understand
	MO1:5: Describe the situation of sampling and non-	

	sampling errors in a statistical study	Understand
Module II	MO 2.1: Apply principle of counting techniques in permutation and combinations MO 2.2: Describe Random experiment, sample space, simple and compound events MO2.3: Explain definitions of probability through classical and frequency approaches. MO 2.4: Compute probability of an event using addition theorem	Apply Understand Understand Apply
Module III	MO 3.1: Explain the concepts of conditional probability, multiplication theorem MO 3.2: Describe independence of events MO 3.3: Identify independence of events MO 3.4: Explain Bayes' theorem MO 3.5: Use Bayes' theorem to compute posteriori probability	Apply Apply Apply Understand Apply
Module IV	MO 4.1: Describe random variables, discrete and continuous types MO 4.2: Explain probability mass function, probability density function and distribution function MO 4.3: Properties of probability mass function MO 4.4: Analyse properties of probability mass function MO 4.5: Describe expectation of a random variable	Understand Understand Understand Analyse Apply
Module V	MO5.1: Explain the situations in which binomial, Poisson and normal distributions are applied MO5.2: Describe various statistical properties of these probability models MO5.3: Explain the procedure of computing - area of a normal curve	Apply Apply Analyse

Module VI (only for practical exam.)	MO 6.1: Use R functions to computation of measures of dispersion, correlation and regression and curve fitting.	Apply

Course content

Module I: Data collection Population, sample, census, primary data, secondary data, sample unit, sampling frame, sampling methods- probability and non-probability sampling, basic concepts of simple random sampling, stratified and systematic sampling, sampling and non-sampling errors.

Module II: Probability 1: Fundamental principle of counting, permutation and combinations, Random experiment, sample space, equally likely outcomes, simple and compound events, mutually exclusive and exhaustive events, definitions of probability- classical and frequency approaches, axioms of probability, addition theorem for two and three events (basic concepts and problems only; mathematical derivations are not required)

Module III: Probability 2: Conditional probability, multiplication theorem, statistical independence, Bayes' theorem to calculate posteriori probability (statement and problems only, mathematical derivation is not required)

Module IV: Random variables: discrete and continuous types, probability distribution-probability mass (definition, properties and simple problems), distribution function (definition and properties), probability density function (definition and properties only). Mathematical expectation of random variables (problems on discrete case only)

Module V: Standard distributions: Bernoulli, binomial, Poisson (mean, variance and additive property only and no derivation is required) and normal distribution (basic properties and evaluation of probabilities using statistical table)

Module VI: Practical problems using R (for practical examination only) Computation of measures of dispersion, correlation and regression and curve fitting. (Practical Sheets 5 to 7)

References:

1. Agarwal, B.L. (2006). Basic Statistics, 4th Edition, New Age International(P) Ltd, New Delhi

2. Des Raj and Pramod Chandhok (1998): Sample Survey Theory, Narosa Publishing House, New Delhi

3. Gupta S.C and Kapoor, V.K. (1990). Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

4. Gupta S.P (2004). Statistical Methods, Sultan Chand and Sons, New Delhi.

5. John Silk (1978). Statistical Concepts in Geography, George Allan and Unwin

6. John E Freund and Ronald E Walpole (1982): Mathematical Statistics, 4th Edition,

Prendice Hall

6. Medhi J (2000) Statistical Methods - An introductory text, New Age International(P), Ltd, New Delhi

Semester III

Course - III

ST 1331.3 Statistical Inference

Course outcomes

On completion of the course, the students should be able to:
CO.1 Explain the concepts of parameter, statistic and sampling distribution.
CO.2 Define the chi-square, t and F distributions, state their inter relationships and describe their uses.
CO.3 Describe the concept of point estimation and explain the desirable properties of a good estimator
CO.4 Apply the method of moments to estimate the parameters of a distribution.
CO.5 Find the confidence interval for mean and proportion.
CO.6 Explain the basic concepts of testing of hypothesis and describe the procedure of the testing of a statistical hypothesis
CO.7 Apply the test procedures for testing the hypothesis of mean and proportion, both in small and large sample cases.
CO.8 Practical: Use R functions to solve numerical problems associated random sampling, standard and sampling distributions, and fitting of distributions.

Module outcomes

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE I	MO 1.1 Explain the concepts- parameter, statistic and sampling distributions.	Understand
	MO 1.2 Define chi-square, t and F distributions along with the examples of statistics following these distributions.	Understand
	MO 1.3 Describe the uses of normal, chi-square, t and F Distributions.	Understand
	MO 1.4 State the inter relationships of chi-square, t and F	Remember

	distributions. MO 1.5 State the central limit theorem.	 Remember
MODULE II	MO 2.1Describe the concept of point estimation. MO 2.2 Describe the desirable properties of a good estimator. MO 2.3 Obtain the confidence interval for mean and proportion from a large sample.	Understand Understand Apply
MODULE III	MO 3.1 Describe the basic concepts of testing of hypothesis. MO 3.2 Define simple and composite hypotheses with examples. MO 3.3 Explain the procedure of testing a statistical hypothesis. MO 3.4 Describe the types of errors in testing of hypothesis. MO 3.5 Describe the level of significance.	Understand Remember Understand Understand Apply
MODULE IV	MO 4.1 Carryout the test for mean of a population and equality of means of two populations. MO 4.2Carryout the test for proportion of a population and equality of two proportions. .	Analyse Analyse
MODULE V	MO 5.1 Carryout the test for mean of a population and equality means of two populations. MO 5.2 Carryout the paired t test. MO 5.3 Carryout the chi-square test of variance. MO 5.4 Carryout the F- test of equality of variances.	Analyse Analyse Analyse Analyse
MODULE VI (only for practical exam)	MO 6.1 R functions: random sampling, standard and sampling distributions, and fitting of distributions.	Apply

Course content

Module I: Sampling distributions: Parameter, statistic, sampling distribution, distribution of sample mean, chi-square, Student's t and Snedecor's F distributions (definitions and statistics following these distributions without derivations), uses, inter-relationships. Central limit theorem (statement only)

Module II: Estimation: Point estimation- estimator, estimate, desirable properties of good estimator, method of moments, interval estimation- confidence interval for mean and proportion for large samples.

Module III: Testing hypothesis: Statistical hypothesis- null hypothesis, alternate hypothesis, simple and composite hypothesis, decision problem in testing hypothesis- type of errors and level of significance, p-value (concept only).

Module IV: Large sample test: One sample test for mean, test of equality of means of independent samples, test of proportion for one sample, test of equality of proportions.

Module V: Small sample tests: One sample test for mean, test of equality of means of independent samples, paired t-test, chi-square test for variance, F-test for equality of variances.

Module VI: For practical examination only: random sampling, standard and sampling distributions, and fitting of distributions. Practical Sheets 8 – 10.

Semester IV

Course - IV

ST 1431.3 Statistical Techniques for Geography

Course Outcomes

On completion of the course, the students should be able to:

CO 1 : Explain the concepts of non- parametric inference, its advantages and limitations along with the application of chi-square distribution in testing good ness of fit and independence of attributes.

CO 2: Describe the test procedure for one sample non parametric tests (median) such as sign test, Wilcoxon signed rank test, KS test and run test for randomness.

CO3: Describe the testing procedure for two sample non parametric tests (equality of medians) such as median test, Mann-Whitney U test, Run test, KS test.

CO4: Discuss the concept of ANOVA and to illustrate the testing procedure for one way ANOVA and two- way ANOVA.

CO 5: Description about the testing procedure of Kruskal Wallis test (nonparametric analogue of one -way ANOVA.)

CO6: Explain the concepts of various point patterns and area patterns along with description about quadrat analysis, contiguity test and auto correlation structure.

CO7: Practical based on R software to test various hypotheses problems.

Module Outcomes

Sl.No	Outcomes	Taxonomy Level
Module 1	MO 1.1: Explain the concept of non- parametric inference and its merits and limitations. MO 1.2: Carry out Chi-square test of good ness of fit MO 1.3: Carry out Chi-square test of independence/association/homogeneity	Understand Analyse Analyse
Module II	MO 2.1: Describe about one sample non parametric tests	Understand

	MO 2.2: Discuss various statistical tests such as sign test, Wilcoxon signed rank test, KS test, run test for randomness. MO 2.3: Carry out one sample non parametric tests	Understand Analyse
Module III	MO 3.1: Explain two sample non parametric test MO 3.2: Discuss two sample non parametric tests such as Median test, Mann Whitney U test, run test, KS test. MO 3.3: Perform two sample non parametric tests.	Understand Understand Analyse
Module IV	MO 4.1: Discuss the concept of ANOVA MO 4.2: Description about one way ANOVA and two-way ANOVA MO 4.3: Carry out one- way ANOVA and two- way ANOVA MO 4.4: Perform Kruskal Wallis test	Understand Understand Analyse Analyse
Module V	MO 5.1: Introduce point pattern and discuss various point patterns (random and systematic patterns) MO 5.2: Explain area patterns such as Lattice pattern, regular and irregular patterns. MO 5.3: Description about quadrat analysis, contiguity test and spatial data. MO 5.4: Discuss auto correlation structure, definitions of variogram and semi variograms	Understand Understand Understand Understand
Module VI (only for Practical exam)	MO 6.1: Use R functions for various tests of hypotheses.	Analyze

Course content

Module I: Introduction to non-parametric inference, its advantages and disadvantages, Chi square test of goodness of fit (binomial and Poisson distributions), Chi-square test of independence/association/homogeneity. (concepts and problems only, derivations not required).

Module II: One sample non parametric tests: sign test, Wilcoxon's signed rank test, Kolmogorov-Smirnov test, run test for randomness (concepts and problem only. Derivation not required)

Module III: Two sample non parametric tests: median test, Mann-Whitney U test, run test, Kolmogorov -Smirnov test (concepts and problems only. Derivation not required)

Module IV: Analysis of variance: one way ANOVA, two- way ANOVA, Kruskal Wallis test (concepts and problem. Derivations not required)

Module V: Point patterns: random and systematic point patterns, quadrat analysis; area pattern: lattice patterns- regular and irregular (elementary level), contiguity test (only for regular pattern at elementary level), concept of spatial data, auto correlation structure, definitions of variograms, semi-variograms

Module VI: Practical problems using R (for practical examination only). Tests of hypotheses, one way and two way ANOVA. (Practical Sheets 11 and 12)

References:

1. Ebson, D., Blackwell, B (1977). Statistics in Geography- A Practical Approach

2. Gupta S.C and Kapoor, V.K. (1990). Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

3. Gupta S.P (2004). Statistical Methods, Sultan Chand and Sons, New Delhi.

4. Silk, J (1979). Statistical Concepts in Geography, George Allan and Unwin, London.

5. John E Freund and Ronald E Walpole (1982). Mathematical Statistics, 4th Edition, Prendice Hall

6. Medhi J (2000) Statistical Methods- An introductory text, New Age International (P) Ltd, New Delhi

7. Murray R Spiegel and Larry J Stephen (1998). Statistics,IV th Edition, Schaums outline series, Mc Graw Hill Education (Pvt Ltd), India.

8. Murray R Spiegel. Larry J Stephen (1 998). Theory and problems of Statistics, Schaums outline series, Mc Graw Hill Education (P) Ltd, India.

9. Saroj K Paul (1982) Statistical techniques: A basic approach in Geography, Tata McGraw Hill Education.

Semester IV

Course - V

ST 1432.3 **Practical using R**

Any standard version of R in any operating system can be used. The Record book is mandatory to appear for the Practical examination and the Record book should contain following Practical sheets based on Module VI of Courses ST1131.3 to ST1431.3. Minimum number of questions covering all functions/methods given therein must be included in each practical sheet along with their R codes, outputs and interpretations / conclusions.

Practical Sheet - 1: Data Types in R

Basics of vector, matrix and data frame, basic functions – c( ), sequence( ), scan( ), factor( ) table( ), and cut( ).

Minimum number of questions – 12

Practical Sheet - 2: Frequency Tables

Forming ungrouped and grouped frequency tables with raw data using table and cut functions.

Minimum number of questions – 5

Practical Sheet - 3: Graphical Methods

Simple bar plot, multiple bar plot (side by side and subdivided), pie chart, histogram, scatter plot, plot function and lines function.

Minimum number of questions - 8

Practical Sheet - 4: Measures of Central Tendency

Descriptive measures: sum, sort, min, max, length, mean, median, mode (using sort and table).

Minimum number of questions - 10

Practical Sheet - 5: Measures of Dispersion

Range, IQR, quartile deviation, sd, var, coefficient of variation, summary.

Minimum number of questions - 10

Practical Sheet - 6: Correlation and Regression

Computation of covariance for a bivariate data using cov(), Pearson's and Spearman's correlation coefficient using cor(). Linear regression models: fitting using lm(), prediction from fitted model.

Minimum number of questions - 6

Practical Sheet - 7: Curve Fitting

Fitting of a straight line, $y = ax^2 + bx + c, a \neq 0$; $y = ae^{bx}$, where a, b *and* c are real constants.

Minimum number of questions – 5

Practical Sheet - 8: Random Sampling and Standard Distributions

SRSWOR and SRSWR using sample(). Binomial, Poisson, normal– The **d**, **p** and **r** functions, the scale function, evaluation of probabilities using these functions. Random number generation.

Minimum number of questions - 12

Practical Sheet - 9: Fitting of Distributions

Fitting of binomial, Poisson and normal distributions.

Minimum number of questions - 3

Practical Sheet - 10: Sampling Distributions

Chi-square, t and F distributions - The **d**, and **p** functions, evaluation of probabilities using these functions.

Minimum number of questions - 8

Practical Sheet - 11: Testing of Hypothesis

Testing of hypothesis: prop.test (one sample and two sample), t.test (one sample, two sample, and paired), chi squared tests (goodness of fit, and independence of attributes). F test for equality of variances.

Minimum number of questions - 8

Practical Sheet - 12: Analysis of Variance

Analysis of Variance: One way anova and two way anova with one observation per cell.

Minimum number of questions – 4

References:

1. Dalgaard, P.(2008). *Introductory Statistics with R*, Springer, New York.

2. Kerns, G J. (2010). *Introduction to Probability and Statistics using R.* ISBN-10 : 0557249791
3. Lander J. P. (2017). *R for everyone* 2/e. Addison-Wesley Professional, U. S.
4. Michael J. Craley (2013*). The R Book*, 2/e, Wiley, New York.
5. Purohit, S. G., Deshmukh, S.R., & Gore, S. D. (2008). *Statistics using R.* Alpha Science International, United Kingdom.

Web Resources:

1. https://cran.r-project.org
2. https://cran.r-project.org/manuals.html
3. https://www.r-project.org/other-docs.html
4. https://journal.r-project.org/
5. https://www.r-bloggers.com

UNIVERSITY OF KERALA

FIRST DEGREE PROGRAMME UNDER CBCSS

Revised Scheme and Syllabi in Outcome-Based Education Mode of

Complementary Statistics for Economics Core

(with effect from 2022 Admission)

The goal of the syllabus is that students understand statistics by using it effectively in real life situations. It is aimed that students acquire experience of the application of statistical methods to analyze data and get acquainted with situations where statistical thinking is helpful. Emphasis is given to practical-data collection and use of appropriate statistical tools to analyze them. Numerical problem solving using scientific calculators is also included in the ESE of Courses I, II, III & IV. ESE of Courses I, II, III, & IV will be of 3 hours duration and have questions from all modules. Courses I & II will be of 2 credits each, III & IV will be of 3 credits each.

Course Structure:

Semester	Title of the Course	Hours/Week	Number of Credits	Total Hours/Semester	ESE Duration(Hours)	CE Weightage (%)	ESE Weightage (%)
I	**ST1131.4 Statistics-I**	3	2	54	3	20	80
II	**ST1231.4 Statistics-II**	3	2	54	3	20	80
III	**ST1331.4 Statistics-III**	3	3	54	3	20	80
IV	**ST1431.4 Statistics-IV**	3	3	54	3	20	80

Complementary Course to First Degree Programme for Economics

SEMESTER: I
COURSE CODE: ST 1131.4
COURSE TITLE: STATISTICS – I

Credits: 2; Hours/week: 3

Course outcomes

On completion of the course, the students should be able to:

CO.1: Explain origin and history of Statistics

CO.2: Explain the functions and objectives of NSO and other Statistical Organizations

CO.3: Plan and execute small research investigations

CO.4: Apply various methods of collecting primary and secondary data

CO.5: Use various data visualization methods (diagrams and graphs)

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE 1	MO 1.1:Explain origin and development of Statistics MO 1.2:Describe importance of Statistics in various fields MO 1.3:Explain descriptive and inferential statistics in the analysis of data MO 1.4:Describe Misuse of Statistics by non-statisticians	Understand Remember Remember Remember Understand
MODULE 2	MO 2.1:Describe Indian Statistical System MO 2.2:Describe functions and activities of MOSPI MO 2.3:Describe functions and objectives of NSO MO 2.4:Explain activities of Department of Economics and Statistics, Government of Kerala	Understand Understand Understand Understand

MODULE 3	MO 3.1:Distinguish Primary and Secondary data	Understand
	MO 3.2:Define Nominal, Ordinal, Interval and Ratio scales	Remember
	MO 3.3:Build questionnaires and schedules for investigation	Create
	MO 3.4:Describe census and sampling	Understand
	MO 3.5:Define and illustrate probability and non-probability sampling methods	Understand
MODULE 4	MO 4.1:Define classification and tabulation	Remember
	MO 4.2:Distinguish ungrouped and grouped frequency distributions	Analyze
	MO 4.3:Construct relative and cumulative frequency tables	Apply
	MO 4.4:Construct frequency tables from raw data	Apply
MODULE 5	MO 5.1:Construct various diagrams and graphs	Apply
	MO 5.2:Apply diagrams and graphs to represent economic data	Apply
	MO 5.3:Determine median from ogives	Evaluate

Course content

Module I

Origin and development of Statistics: Origin and history of Statistics, various definitions of Statistics in 'plural' and 'singular' sense, Statistical methods, Descriptive Statistics, Inferential Statistics, Applied Statistics, importance and scope of Statistics, functions, limitations and misuse of Statistics, applications of Statistics in the field of Economics.

Module II

Brief introduction to Indian Statistical System: Overview of Indian Statistical System, objectives and functions of National Statistical Office (NSO), Directorate of Economics and Statistics under Government of Kerala, Statistical activities carried out by various reputed departments under Central/State Governments, overview of Ministry of Statistics and Programme Implementation (MOSPI),

Module III

Methods of data collection: Nominal, ordinal, interval and ratio scales, primary data and secondary data, Methods of collecting primary data along with its merits and demerits, sources of secondary data, scrutiny of secondary data, census and sample surveys, advantages and limitations of sampling, Selection of sample using simple random sampling, stratified random sampling, systematic sampling, cluster sampling, multistage sampling (procedure with examples only and no need of estimation), convenient sampling, purposive sampling, judgement sampling, quota sampling, snowball sampling (definitions and examples only)

Module IV

Classification and tabulation: Classification and tabulation, types of classification, types of tabulation, frequency distribution and frequency table, tally marks, discrete and continuous frequency distribution, relative frequency table, cumulative frequency table, uses, merits and demerits of frequency tables.

Module V

Diagrams and graphs: Diagrammatic and graphical representation of data, different types of bar diagram, pie-diagram, cartogram, pictogram, histogram, frequency polygon, frequency curve, relative frequency curve, ogives, methods of finding percentiles from ogives

REFERENCES:

1. B.L. Agarwal (2017). *Programmed Statistics,* New Age International Publishers, New Delhi,
2. Elhance D.N., Veena Elhance and B.M. Agarwal (2018). *Fundamentals of Statistics,* Kitab Mahal Publications, New Delhi.
3. S.P. Gupta (2019). *Statistical Methods*, Sultan Chand & Sons, New Delhi
4. S.C.Gupta and V.K.Kapoor (2021). *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi
5. Goon, Gupta, Das Gupta (2016). *Fundamentals of Statistics,* The World Press
6. Basic Statistics relating to Indian Economy (CSO Publication) 1990
7. Statistical System in India (CSO Publication), 1995.

ONLINE REFERENCES

https://www.mospi.gov.in/

http://www.ecostat.kerala.gov.in/

Complementary Course to First Degree Programme for Economics

SEMESTER: II

COURSE CODE: ST 1231.4

COURSE TITLE: STATISTICS-II

Credits: 2; Hours/week: 3

Course Outcomes

On completion of the course, students should be able to:
CO.1: Calculate the various measures of central tendency, dispersion, partition values, percentile rank and skewness.
CO.2: Articulate the concept of kurtosis and calculate the coefficient of kurtosis.
CO.3: Construct Lorenz curve and comment on the variability of data sets.

CO.4: Locate partition values such as quartiles, deciles, percentiles graphically.

CO.5: Fit various curves to data sets.

Module Outcomes

Module	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module 1.	MO 1.1 Calculate the Measures of central tendency.	Apply
	MO 1.2 Differentiate between the various measures of central tendency based on their applications and uses.	Evaluate
	MO 1.3 Articulate the merits and demerits of various measures of central tendency.	Understand
	MO 1.4 Compare two or more datasets based on average and comment on their performance.	Evaluate
Module: 2	MO 2.1 Articulate concepts of Partition values- Quartiles, Deciles, Percentiles; Percentile Rank.	Understand
	MO 2.2 Distinguish between the Partition values- Quartiles, Deciles, Percentiles; Percentile Rank.	Analyse
	MO 2.3 Articulate the uses and applications of partition values.	Understand
	MO 2.4. Graphically locate the partition values for a given data set.	Evaluate

Module 3	MO 3.1 Calculate the absolute measures and relative measures of dispersion. MO 3.2 Describe the applications and uses of various measures of dispersion. MO 3.3 Compare two or more data sets using absolute and relative measures of dispersion. MO 3.4 Construct Lorenz curve and make inference for the data sets.	Apply Analyse Apply Apply
Module 4	MO 4.1 Calculate absolute and relative measures of skewness for data set and comment on the same. MO 4.2 Define kurtosis and various types of kurtosis . MO 4.3 Calculate coefficient measure of kurtosis. MO 4.4 Compare the data sets using absolute and relative measures of skewness and coefficient of kurtosis.	Apply Understand Apply Evaluate
Module 5	MO 5.1 Explain the concept of Curve fitting and Principles of least squares. MO 5.2 Apply least squares methods for fitting first degree and second degree polynomials. MO 5.3 Apply least squares methods for fitting power curves and exponential curves. MO 5.4 Fit the curves for the given data set.	Understand Apply Apply Evaluate

COURSE CONTENT

Module I

Measures of central tendency – Definition, Various measures of central tendency – Arithmetic Mean, Median, Mode, Geometric Mean, Harmonic Mean, Properties, Uses, Merits and demerits of various measures.

Module II

Partition values – Quartiles, Deciles, Percentiles, Percentile Rank, Uses, Graphical representation of partition values.

Module III

Measures of dispersion – Definition, Absolute and relative measures of dispersion, Desirable properties, Uses, Merits and demerits of various measures; Lorenz curve - Uses and limitations.

Module IV

Skewness and Kurtosis: Skewness - Definition, Types of skewness, Absolute and relative measures of skewness; Kurtosis – Definition, Types of kurtosis, Coefficient measure of kurtosis (Moment measures of skewness and kurtosis not required).

Module V

Curve fitting and Principle of least squares – Fitting of first degree and second degree polynomial, power curves and exponential curves.

REFERENCES:

1. B.L. Agarwal (2017). *Programmed Statistics*, New Age International Publishers, New Delhi,
2. Elhance D.N., Veena Elhance and B.M. Agarwal(2018). *Fundamentals of Statistics*, Kitab Mahal Publications, New Delhi.
3. S.P. Gupta (2019). Statistical Methods, Sultan Chand & Sons, New Delhi
4. S.C.Gupta and V.K.Kapoor (2021). *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi
5. Goon, Gupta, Das Gupta (2016). *Fundamentals of Statistics*, The World Press

Complementary Course to First Degree Programme for Economics

SEMESTER: III
COURSE CODE: ST 1331.4
COURSE TITLE: STATISTICS – III

Credits: 3; Hours/week: 3

Course outcomes

On completion of the course, the students should be able to:

CO.1: Interpret the strength of relationship exists between economic variables

CO.2: Predict the value of a dependent variable using past data set

CO.3: Explain the association between two qualitative variables

CO.4: Differentiate between coefficient of correlation and coefficient of association

CO.5: Define various simple and weighted price (quantity) index numbers

CO.6: Define the probability of uncertain events mathematically

CO.7: Define binomial, Poisson and normal distributions

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE 1	MO 1.1:Plot the data on two variables in scatter diagram	Remember
	MO 1.2:Define linear relationship between two quantitative variables	Remember
	MO 1.3:Calculate the degree of linear relationship between two variables	Apply
	MO 1.4:Define relationship between qualitative variables	Remember
	MO 1.5:Apply the concept of linear correlation in the analysis of Economic data	Apply

MODULE 2	MO 2.1:Define regression	Remember
	MO 2.2:Construct two regression lines	Apply
	MO 2.3:Use regression lines for prediction	Apply
	MO 2.4:Describe the need of two regression lines	Understand
	MO 2.5:Model relationship between two economic variables for forecasting	Analysis
MODULE 3	MO 3.1:Define various types of associations	Remember
	MO 3.2:Describe the various types of associations	Understand
	MO 3.3:Assess the degree of association mathematically	Evaluate
	MO 3.4:Calculate the missing frequencies in contingency tables	Evaluate
	MO 3.5:Define partial and illusory association	Remember
MODULE 4	MO 4.1:Define the concept of index numbers	Remember
	MO 4.2:Calculate simple and weighted index numbers	Evaluate
	MO 4.3:Apply tests for consistency of index numbers	Apply
	MO 4.4:Calculate the cost of living index number	Evaluate
	MO 4.5:Describe the limitations of index numbers	Understand
MODULE 5	MO 5.1:Define random and deterministic experiments	Remember
	MO 5.2:Define various types of events	Remember
	MO 5.3:Describe classical and frequency approaches to probability	Understand
	MO 5.4:Define discrete and continuous random variables	Remember
	MO 5.5: Define binomial, Poisson and normal distribution	Remember

Course content

Module I

Correlation Analysis: Linear Correlation, positive and negative correlation Scatter diagram, Karl Pearson's coefficient of correlation, properties of correlation coefficient

(no derivation), probable error, Spearman's rank correlation including tied ranks (no derivation)

Module II

Regression Analysis: Simple linear egression, derivation of simple linear regression equations using principle of least squares theory, regression coefficients and properties (no derivation), point of intersection two regression lines, identification of two regression lines, angle between two regression lines, standard error estimates.

Module III

Association of attributes(dichotomous classification): Consistency of data, methods of studying association - Yule's coefficient of association, coefficient of colligation, Definitions of partial and illusory association

Module IV

Index Numbers: Index numbers, Price and quantity index numbers, Simple and weighted index numbers, Laspeyre's, Paasche's, Marshall - Edgeworth's, Drobish Bowley's, Fisher's and Kelly's index numbers, Time reversal, Factor reversal and Circular tests, Consumer price index number.

Module V

Probability distributions: Random Experiment, sample space, events, simple and composite events, exhaustive, mutually exclusive, equally likely and independent events, classical definition of probability, frequency definition of probability, its limitations; elementary properties of probability, addition theorem for two events, concept of odds in favour of and against an event, concept of conditional probability of two events, simple problems on probability, random variable; probability mass function and probability density function (definition, properties and simple examples), binomial distribution (PMF, mean and variance (no derivation), simple examples to find binomial probabilities), Poisson distribution (PMF, mean and variance (no derivation), real life examples of events following Poisson distribution, simple problems to compute Poisson probabilities) and Normal distribution (PDF, mean and variance (no derivation), important properties, simple examples to find area under standard normal curve).

REFERENCES:

1. B.L. Agarwal (2017). *Programmed Statistics*, New Age International Publishers, New Delhi,
2. Elhance D.N., Veena Elhance and B.M. Agarwal (2018). *Fundamentals of Statistics*, Kitab Mahal Publications, New Delhi.
3. S.P. Gupta (2019). *Statistical Methods*, Sultan Chand & Sons, New Delhi
4. S.C.Gupta and V.K.Kapoor (2021). *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi
5. Goon, Gupta, Das Gupta (2016). *Fundamentals of Statistics*, The World Press

Complementary Course to First Degree Programme for Economics

SEMESTER: IV

COURSE CODE: ST 1431.4

COURSE TITLE: STATISTICS-IV

Credits: 3; Hours/week: 3

Course Outcomes

On completion of the course, students should be able to:

CO. 1: Formulate hypothesis and identification of the appropriate methods of testing for a given problem.

CO. 2: Differentiate between parametric and non parametric test and their applications in real data.

CO. 3: Execute testing of significance of mean, proportion, difference between means, difference between proportions in the case of a large sample.

CO. 4: Execute testing of significance of mean, difference between means, correlation coefficient, variance in the case small samples.

CO. 5: Compute and interpret one-way Analysis of variance

CO. 6: Perform non-parametric test for given data set(s).

CO. 7: Understand the basic concepts and tools in time series analysis and apply it for a time series data.

CO. 8: Create graphical representation for measuring trend in a time series data.

Module Outcomes

Module	Outcomes On completion of each module, students should be able to:	Taxonomy Level
Module 1.	MO 1.1 Reciprocate the basic concepts used in testing of hypothesis.	Understand
	MO 1.2 Formulate hypothesis and identify the appropriate test statistic for a given problem.	Apply
	MO 1.3 State the interrelationship between Normal, Chi-square , t and F statistic.	Remember
	MO 1.4 Calculate Significance level and Power of the test.	Evaluate
Module: 2	MO 2.1 Recollect the test concerning significance of mean, proportion in the case of large sample.	Remember
	MO 2.2 Recollect the test concerning significance of difference between means and difference between proportions in the case of large samples.	Remember
	MO 2.3 Carry out the test concerning significance of mean significance of mean, proportion in the case of large sample taken from a population and interpret it.	Apply
	MO 2.4. Carry out the test concerning significance of difference between means and difference between proportions in the case of large samples, and interpret it.	Apply
Module 3	MO 3.1 Recollect the test concerning significance of mean, correlation coefficient, variance in the case of small sample.	Remember
	MO 3.2 Recollect the test concerning significance of difference between means in the case of small samples.	Analyze
	MO 3.3 Carry out the test concerning significance of mean, correlation coefficient, variance in the case of small sample taken from a population and interpret it.	Apply
	MO 3.4. Carry out the test concerning significance of difference between means and difference between proportions in the case of large samples and interpret it.	Apply

	MO 3.5 Compute and interpret one – way analysis of variance . .	Apply
Module 4	MO 4.1 Reckoning the concept of nonparametric test and nonparametric test procedures (- Chi-square test of goodness of fit, Chi-square test of independence of attributes, Fisher's exact test, Sign test, Wilcoxon's signed rank test, Mann-Whitney-Wilcoxon test, Kruskal Wallis test). MO 4.2 Compute and interpret nonparametric test for the given data set(s). MO 4.3 Identify and apply Yate's correction in Chi-square test for a given problem. MO 4.4 Compare the application of various nonparametric test .	Understand Apply Apply Analyze
Module 5	MO 5.1 Reckoning the basic concepts of time series analysis and visualizing time series data. MO 5.2 Fitting of trend by Moving Average method, measurement of seasonal indices by Ratio-to-Trend , Ratio-to-Moving Average. MO 5.3 Graphically represent the trend in time series data by applying principle of least squares method. MO 5.4 Compare the merits and demerits of the methods used in analysing trend and seasonal variations in time series data	Remember Apply Create Analyze

COURSE CONTENT

Module I

Sampling Distribution and Testing of Hypothesis – Definition of Statistic, parameter, sampling distribution and standard error, Examples of statistics following Chi- square, t and F distributions, Relationship between Normal, Chi-square, t and F distributions, Concepts of statistical hypothesis, Simple and composite hypothesis, Null and alternate hypothesis, One-tailed and two-tailed tests, Type I and type II errors, Size, Level of significance and power of tests, p –value, Various steps involved in testing statistical hypothesis.

Module II

Large sample tests – Tests concerning significance of mean, difference between means, significance of proportion, difference between proportions.

Module III

Small Sample Tests: Tests concerning significance of mean, difference between means, significance of correlation coefficient, Chi-square test of variance (with assumptions), One – way analysis of variance.

Module IV

Non – parametric tests - Chi-square test of goodness of fit, Chi-square test of independence of attributes, Yate's correction, Fisher's exact test, Sign test, Wilcoxon's signed rank test (One sample and paired sample), Mann-Whitney-Wilcoxon test (Two independent samples), Kruskal Wallis test.

Module V

Time Series Analysis – Definition, Uses, Components of time series, Analysis of time series – Measurement of trend – Graphic method, Method of semi-averages and method of curve fitting by the principle of least squares; Measurement of seasonal variation – Ratio to trend method, Ratio to moving average method; Merits and demerits of these methods.

REFERENCES:

1. B.L. Agarwal (2017). *Programmed Statistics,* New Age International Publishers, New Delhi,
2. Elhance D.N., Veena Elhance and B.M. Agarwal (2018). *Fundamentals of Statistics*, Kitab Mahal Publications, New Delhi.

3. S.P. Gupta (2019). *Statistical Methods*, Sultan Chand & Sons, New Delhi
4. S.C.Gupta and V.K.Kapoor (2021). *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi
5. Goon, Gupta, Das Gupta (2016). *Fundamentals of Statistics*, The World Press

UNIVERSITY OF KERALA

FIRST DEGREE PROGRAMME UNDER CBCSS

REVISED SCHEME AND SYLLABI IN OUTCOME-BASED EDUCATION MODE

OF

COMPLEMENTARY STATISTICS FOR BSc PSYCHOLOGY

(with effect from 2022 Admission)

The goal of the syllabus is that students understand Statistics by using its methods effectively in real life situations. It is aimed that students have experience of the application of statistical methods to analyse data and get acquainted with situations where statistical thinking is helpful. Emphasis is given to practical data collection and use statistical tools to analyse them. Numerical problem solving using scientific calculators is also included in the ESE of courses I, II, III and IV. ESE of Courses I, II, III & IV will be of 3 hours duration and have questions from all modules. Courses I & II will be of 2 credits each and Courses III & IV will be of 3 credits each.

Course Structure:

Sem	Title of the Course	Hrs/ Week	No. of Credits	Total Hrs/Sem	ESE Duration	Evaluation weightage	
		L				CE	ESE
I	ST1131.5: Statistical Methods for Psychology I	3	2	54	3hrs	20%	80%
II	ST1231.5:Statistical Methods for Psychology II	3	2	54	3hrs	20%	80%
III	ST1331.5:Statistical Methods for Psychology III	3	3	54	3hrs	20%	80%
IV	ST1431.5:Statistical Methods for Psychology IV	3	3	54	3hrs	20%	80%

SEMESTER: I

COURSE CODE: ST 1131.5

COURSE TITLE: STATISTICAL METHODS FOR PSYCHOLOGY I

Course outcomes:

On completion of the course, the students should be able to:

CO.1: Explain the importance and functions of Statistics.

CO.2: Explain the concept of linear equations, ratios and theory of indices

CO.3: Describe different variables of measurements and scaling techniques.

CO.4: Explain different data types - primary and secondary data, different methods of primary data collection.

CO.5: Explain the concept of census and sampling, different sampling techniques.

CO.6: Design questionnaires and carry out surveys.

CO.7: Describe different methods of classification of data and present raw data using frequency tables as well as appropriate diagrams and graphs

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE 1	MO1.1 Describe meaning, importance and functions of Statistics. MO 1.2 Discuss the concept of linear equations, theory of indices and ratios MO 1.3 Describe different variables of measurements - qualitative, quantitative, discrete and continuous MO 1.4 Define different scaling techniques-nominal, ordinal, interval and ratio scales	Understand Understand Understand Remember
	MO 2.1 Explain different data types - primary and secondary data and distinguish between the two.	Understand

MODULE 2	MO 2.2 Describe different methods of collecting primary data. MO 2.3 Explain sources of secondary data, precaution in the use of secondary data. MO 2.4 Prepare questionnaire and test reliability, validity and objectivity of it.	Understand Understand Apply
MODULE 3	MO 3.1 Compare census and sampling methods MO 3.2 Explain advantages of sampling over census MO 3.3 Distinguish between random and non-random sampling methods MO3.4 Define simple random sampling, stratified sampling, systematic sampling, multi- stage sampling and cluster sampling MO 3.5 Explain merits and demerits of different sampling models.	Understand Understand Understand Remember Understand
MODULE 4	MO 4.1 Describe different methods of classification MO 4.2 Prepare discrete and continuous frequency tables MO 4.3 Define class limits, class boundaries and class mark. MO4.4 Prepare cumulative frequency tables and cumulative percentage frequency tables	Understand Apply Remember Apply
MODULE 5	MO 5.1 Explain different diagrammatic representations of data like one-dimensional, two-dimensional, three-dimensional, pictograms and cartograms MO 5.2 Sketch different diagrams like bar diagrams, pie diagrams MO 5.3 Visualise frequency distributions using histogram, frequency polygon, frequency curves and ogives.	Understand Apply Apply

Course Content

Module I

Meaning of Statistics, Functions of Statistics, Need and Importance of Statistics in Psychology. Limitations of Statistics.

Prerequisites for studying Statistics - Essential Mathematical fundamentals - solving linear equations, Theory of indices, Ratios.

Types of variables employed in measurements – discrete and continuous variable, quantitative variables. Scale of measurement Nominal scale, Ordinal scale, Interval scale, Ratio scale with suitable examples from Psychological data.

Module II

Collection of Data: Primary data and secondary data, Choice between primary and secondary data. Methods of collecting primary data, merits and demerits of different methods of collecting primary data, Sources of secondary data, Precaution in the use of secondary data. Testing reliability, validity and objectivity of questionnaire.

Module III

Census and sampling method. Methods of sampling – Random sampling and Non-random sampling, Stratified sampling, systematic sampling, Multi stage sampling, Cluster sampling. Selection of appropriate sampling method, Merits and demerits of different sampling methods.

Module IV

Classification and Tabulation: Meaning and objective of classification, Type of classification- geographical classification,Chronological classification, quantitative classification .

Tabulation of data, Formation of discrete and continuous frequency distribution. Class limits, class boundaries, class mark, raw data, ungrouped and grouped data. Cumulative frequencydistribution, cumulative percentage frequency distribution

Module V

Diagrammatic Representations - Bar diagrams, types of Bar diagrams, Pie diagram, Pictograms and cartograms. Graphical representations: Histogram, Frequency polygon, frequency curve, Ogives.

References:

1. Aron A, Aron R & Coups E J (2006). *Statistics for Psychology* (4thed), Pearson Education, New Delhi .

2. Garret E Henry (2004). *Statistics in Psychology and Education* (11thed), Paragon International Publishers, New Delhi.

3. Gravetter, F J & Wallnau L B (2000). *Statistics for Behavioral Science* (5thed), Wadsworth-Thomson learning Singapore

4. Heiman W Carry (2000). *Basic Statistics for Behavioral Science* (3rd ed.), Houghton Mifflin Company, New York

5. Mangal S K (2000). *Statistics in Psychology and Education* (2nd ed.), Prentice_Hall of India Private Limited, New Delhi

6. Minium W Edward, King M Bruce & Bear Gardon (2001). *Statistical Reasoning in Psychology and Education* (3rded),John Wiley & Sons ,New York

7. Yule Undy G & Kendal M G (1991). *An Introduction to Theory of Statistics* (14thed.) Universal Book Stall, New Delhi.

SEMESTER: II
COURSE CODE: ST 1231.5
COURSE TITLE: STATISTICAL METHODS FOR PSYCHOLOGY II

Course outcomes

On completion of the course, the students should be able to:

CO.1: Explain central tendency and properties of good averages

CO.2: Calculate mean, median and mode

CO. 3: Identify median and mode graphically

CO. 4: Calculate percentiles, percentile ranks, quartiles and deciles

CO. 5: Calculate Range, Mean deviation, Quartile deviation and standard deviation.

CO. 6: Compare different measures of variability.

CO. 7: Calculate Karl Pearson's measure of skewness, Bowley's coefficient of skewness and measure of kurtosis.

CO. 8: Calculate probabilities associated with simple numerical problems using classical definition and addition theorem of probability.

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module 1	MO 1.1 Explain central tendency MO 1.2 Explain the properties of a good average MO 1.3 Calculate arithmetic mean, median and mode. MO 1.4 Determine median and mode graphically	Understand Understand Apply Apply
Module 2	MO 2.1 Calculate percentiles, percentile rank MO 2.2 Calculate quartiles and deciles	Apply Apply
Module 3	MO 3.1 Explain variability MO 3.2 Explain properties of a good measure of variability MO 3.3 Calculate Range, Mean deviation, Quartile deviation and standard deviation MO 3.4 Compare different measures of variability. MO 3.5 Calculate coefficient of range, coefficient of quartile deviation and coefficient of variation	Understand Understand Apply Analyse Apply
Module 4	MO 4.1 Explain Skewness and Kurtosis. MO 4.2. Calculate Karl Pearson's measure of skewness, Bowley's coefficient of skewness and measures of kurtosis for raw data (Moment measures of skewness and kurtosis not required)	Understand Apply
	MO 5.1 Explain concepts of set theory and set operations MO 5.2 Explain elementary concepts of probability, random	Understand

Module 5	experiment, sample space and events. MO 5.3 Make use of classical definition of probability and addition theorem (2 events) to calculate probabilities associated with simple numerical problems	Understand Apply

Course content

MODULE I

Meaning and importance of measures of central tendency, Properties of a good average, simple arithmetic mean, mean and weighted mean, arithmetic mean, computation of arithmetic mean for raw, ungrouped and grouped data. Computation of median from raw, ungrouped and grouped data. Computation of mode from raw, ungrouped and grouped data. Graphical determination of median and mode, when to use mean, median and mode.

MODULE II

Percentiles, quartiles and deciles. Computation of percentiles, quartiles and deciles. Percentile rank: definition, computation and utility of percentile and percentile rank.

MODULE III

Meaning and importance the measure of variability, properties of good measure of variability. Range, Mean deviation, Quartile deviation, standard deviation: computation and use. Comparison of different measures of variability. Relative measure of variation-coefficient of range, coefficient of quartile deviation, coefficient of variation, computation and use, when to use various measures of variability.

MODULE IV

Skewness – definition, measures of skewness – Karl Pearson's coefficient of skewness, Bowley's coefficient of skewness. Kurtosis, measures of kurtosis. Simple numerical problems for raw data only. (Moment measures of skewness and kurtosis not required).

MODULE V

Basic concepts of set theory, set operations, probability – random experiment, sample space, event, different types of events. Classical and frequency definition of probability. Addition theorem, independent of events, simple problems.

References:

1. Aron A, Aron R & Coups E J (2006). *Statistics for Psychology* (4thed), Pearson Education, New Delhi .

2. Garret E Henry (2004). *Statistics in Psychology and Education* (11thed), Paragon International Publishers, New Delhi.

3. Gravetter, F J & Wallnau L B (2000). *Statistics for Behavioral Science* (5thed), Wadsworth-Thomson learning Singapore

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6. Minium W Edward, King M Bruce & Bear Gardon (2001). *Statistical Reasoning in Psychology and Education* (3rded),John Wiley & Sons ,New York

7. Yule Undy G & Kendal M G (1991). *An Introduction to Theory of Statistics* (14thed.) Universal Book Stall, New Delhi.

SEMESTER: III

COURSE CODE: ST 1331.5

COURSE TITLE: STATISTICAL METHODS FOR PSYCHOLOGY III

Course outcomes

On completion of the course, the students should be able to:

CO.1: Explain the concept of correlation anddifferent methods of finding correlation like scatter diagram, correlation coefficient.

CO.2: Describe properties of correlation coefficient and solve numerical problems.

CO.3: Describe concept of regression analysis, properties of regression coefficients

CO.4: Explain the concept of association, dissociation and independence of attributes.

CO.5: Describe the concept of random variables-both discrete and continuous, basic concepts and definitions of probability density function and distribution function.

CO.6: Define standard distributions - Binomial and Poisson distributions and derive mean and variance

CO.7: Explain normal probability curve and its characteristics .

CO.8: Compare standard scores like z-score, t-score and stanine score.

Sl. No:	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
MODULE 1	MO1.1 Describe the significance of correlation. MO 1.2 Define different types of correlation like linear, non-linear, direct, inverse. MO 1.3Explain correlation using scatter diagram MO 1.4 Define Pearson's correlation coefficient and describe its properties. MO 1.5Calculate Pearson's correlation coefficient and Spearman's rank correlation coefficient	Understand Remember Understand Understand Apply
MODULE 2	MO 2.1 Explain the concept of regression equations. MO 2.2 Derive angle between regression lines. MO 2.3 Describe properties of regression coefficients. MO 2.4 Derive relation between correlation coefficient and regression coefficients MO 2.5 Explain regression and prediction	Understand Understand Understand Apply Apply
MODULE 3	MO 3.1 Describe the concept of association, dissociation , independence of attributes and consistency of data MO 3.2 Compare correlation and association MO 3.3 Describe different methods of studying association like coefficient of association and coefficient of colligation MO 3.4 Solve simple numerical problems on association	Understand Understand Understand Apply
	MO 4.1 Define random variables-discrete and continuous	Remember

MODULE 4	MO 4.2 Explain the concept and properties of probability density function and distribution function. MO 4.3Solve simple problems of discrete random variables MO 4.4 Define Binomial and Poisson distributions. MO 4.5 Derive mean and variance of Binomial and Poisson distributions MO 4.6 Solve simple numerical problems of Binomial and Poisson distributions	Understand Apply Remember Understand Apply
MODULE 5	MO 5.1 Define Normal curve in terms of skewness and kurtosis MO 5.2 Describe the characteristics of normal curve MO 5.3 Solve numerical problems using Normal tables. MO 5.4 Define standard errors of measurement. MO5.5 Define Standard scores – Z-score, T-Score, Stanine score. .	Remember Understand Apply Remember Remember

Course content

Module I

Correlation Analysis - Significance of the study of correlation, Types of correlation- Linear, Nonlinear correlation, Direct and inverse. Methods of studying correlation: Scatter diagram method, Karl Pearson's coefficient of correlation, Properties of coefficient of correlation, Spearman's rank correlation coefficient (No derivations). Numerical problems

Module II

Significance of the study of regression, difference between correlation and regression analysis. Regression equations - Regression equation of Y on X, Regression equation of X on Y. Regression coefficients, Properties of regression coefficients, Relation between correlation coefficient and regression coefficients. Regression and prediction.

Module III

Difference between Correlation and Association, Consistency of data, Association and Disassociation, Methods of studying Association: Yule's coefficient of association, Coefficient of colligation. Simple numerical problems

Module IV

Random variable, Discrete and continuous random variable, Probability mass function, probability density function, Probability Distributions- Basic concepts, definitions and properties. Problems on discrete random variables. Standard distributions: Binomial, Poisson- definition, Derivation of mean and variance only. simple problems.

Module V

Normal curve – in terms of skewness and kurtosis, Characteristics and applications. Use of the table of Normal curve, Examples of applications of the normal curve. Concept of standard errors of measurement. Standard scores – Z-score, T-Score, Stanine score, Converting raw scores into comparable standard normalized scores.

References:

1. Aron A, Aron R & Coups E J (2006). *Statistics for Psychology* (4thed), Pearson Education, New Delhi .

2. Garret E Henry (2004). *Statistics in Psychology and Education* (11thed), Paragon International Publishers, New Delhi.

3. Gravetter, F J & Wallnau L B (2000). *Statistics for Behavioral Science* (5thed), Wadsworth-Thomson learning Singapore

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7. Yule Undy G & Kendal M G (1991). *An Introduction to Theory of Statistics* (14thed.) Universal Book Stall, New Delhi.

SEMESTER: IV
COURSE CODE: ST 1431.5
COURSE TITLE: STATISTICAL METHODS FOR PSYCHOLOGY IV

Course outcomes

On completion of the course, the students should be able to:

CO.1: Define parameter, statistic, standard error, sampling distributions.

CO.2: Explain chi-square, student's-t and F-statistics and inter relationship between chi-square, t and F distributions.

CO. 3: Make use of tables of student's t, chi square and F distributions.

CO. 4: Calculate interval estimators for mean of normal population

CO. 5: Calculate interval estimators in numerical problems associated with mean of Normal distribution.

CO. 6: Carry out some parametric and non parametric tests of hypothesis.

MODULE OUTCOME

SL. NO	**Outcomes** On completion of each module, students should be able to:	**Taxonomy Level**
Module 1	MO 1.1 Define parameter, statistic, standard error, sampling distributions, Standard error of sample mean	Remember
	MO 1.2 Explain chi-square, student's-t and F-statistics and inter relationship between chi-square, t and F distributions.	Understand
	MO 1.3 Make use of tables of chi square t and F distributions.	Apply
	MO 1.4 Explain basic concepts of point and interval estimation	Understand
	MO 1.5 Calculate interval estimators in numerical problems associated with mean of Normal distribution.	Apply
Module 2	MO 2.1 Explain the basic concepts of testing of statistical hypothesis	Understand
	MO 2.2 Calculate size and power of test in simple problems on discrete cases.	Apply
Module 3	MO 3.1 Carry out large sample tests of significance of mean, proportion, difference between two means and difference between two proportions.	Apply
	MO 3.2 Carry out chi square tests of independence of attributes and goodness of fit.	Apply

	MO 3.3 Define coefficient of contingency	Remember
Module 4	MO 4.1 Carry out small sample tests of the significance of mean and difference between two means in normal population(s) MO 4.2 Carry out paired t test MO 4.3 Carry out test for significance of correlation coefficient.	Apply Apply Apply
Module 5	MO 5.1 Explain non- parametric tests MO 5.2 Carry out sign test, Wilcoxon's matched pair signed rank test, Wald-Wolfowitz run test, Mc-Nemar test	Understand Apply

Course content

Module I

Statistical inference: Parameter, statistic, standard error, sampling distributions, sampling distribution of sample mean (without proof), chi-square, student's-t, F-statistics-definitions, inter relationship between chi-square, t and F statistics, Estimation theory-point and interval estimation (basic concepts, definition only), interval estimation problems based on Normal and t distributions.

Module II

Testing of hypothesis: Procedure of testing of hypothesis, Null and alternative hypothesis, Two types of errors, significance level, power of test, P value, Two tailed and one tailed tests of significance, simple problem on discrete case only.

Module III

Large sample tests: testing the significance of mean, testing the significance of difference between two means, testing significance of proportion, testing significance of difference between two proportions. Chi-square tests- testing independence of attributes, coefficient of contingency, testing of goodness of fit.

Module IV

Small sample tests: testing the significance of mean of normal distribution, testing the significance of difference between means of two normal populations, paired-t tests, testing correlation coefficient.

Module V

Non- parametric tests: when to use parametric and non- parametric tests, Sign test,Wilcoxon's matched pair signed rank test, Wald-Wolfowitz Run test, Mc-Nemer test, Simple problems (for problems table value to be provided in the question paper).

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