MAR IVANIOS COLLEGE
(AUTONOMOUS)
THIRUVANANTHAPURAM

DEPARTMENT OF STATISTICS

Syllabus for B.Sc. Statistics

Academic Year 2022 – 2023 onwards

FIRST DEGREE PROGRAMME IN

STATISTICS

UNDER CHOICE BASED

CREDIT AND SEMESTER SYSTEM

(CBCSS)

MAR IVANIOS COLLEGE
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	AUST 141 Statistical Methods I	2	2	4	72	20%	80%
II	AUST 221 Statistical Methods II (Foundation course 2)	2	2	3	72	20%	80%
III	AUST 341 Probability and Distributions-I	3	2	3	90	20%	80%
IV	AUST 441 Probability and Distributions-II ST 1442 Practical I	3	2	3 3	54 36	20%	80%
V	AUST 541 Limit Theorems and Sampling Distributions	3	2	4	90	20%	80%
	AUST 542 Estimation	3	2	3	90		
	AUST 543 Testing of Hypothesis	3	2	3	90		
	AUST 544 Sample Survey Methods	3	2	4	90		
	AUST 581.5 Open Course 1(Time Series & Forecasting)	3		2	54		
	Project		2	-	36		
VI	AUST 641Design of Experiments and Vital Statistics	4	3	4	126	20%	80%
	AUST 642 Applied Statistics	4	2	4	108		
	AUST 643 Operations Research and Statistical Quality Control	4	2	4	108		
	AUST 64P I Practical II			4			
	AUST 64P II Practical III			3			
	AUST 644 Project		3	4	54		
	AUST 691.c 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	AUST 44P I Practical I	2 hrs	3	1	3	S_1/ S_2 - 2 S_3/S_4 - 2
VI	AUST 64 PI Practical II AUST 64 P II Practical III	2 hrs 2 hrs	4 3	1 1	3 3	S_5 - 8 S_6 - 7
	AUST644 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

AUST 141: 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

AUST 221: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

AUST 341: 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

AUST441: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

AUST 44 P I : 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

AUST 541: 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

AUST 542: 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

AUST 543: 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	Remember
	MO 5.2 Explain Kolmogorov Smirnov one sample and two sample tests	Understand
	MO 5.3 Explain Sign test for one sample and two samples	Understand
	MO 5.4: Describe Run test	Understand
	MO 5.5: Explain Wilcoxon signed rank test.	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*, 4th edition, Collier McMillan.
4. Mood, A.M, Graybill, F.A. and Bose, D.P. (1972). *Introduction to theory of statistics*, 3rd edition–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*, 2nd edition. John Wiley & Sons, Inc., New York.
7. Wilks, S.S(1962). *Mathematical Statistics*, John Wiley, New York.

V Semester- Core Course 9

A U ST 544: 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

AUST 641: 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 MO 1.2 Carry outone way and two way ANOVA	Understand Apply
Module: II	MO 2.1 Compare CRD, RBD and LSD. MO 2.2 Carry out RBD and LSD designs with one or two missing observations. MO 2.3 Explain the efficiencies of RBD over CRD, LSD over RBD and LSD over CRD	Analyze Analyze 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

AUST 642: 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

AUST 643: 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

AUST 644 P I 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

AUST64 P II: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

AST 644: Project / Internship

VI Semester: Open Course 2

AUST 691.c: 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.

AUST 1661.1: Biostatistics

ST 1661.2**:** Econometric Methods

AUST 691.c: Inventory Control and

Queuing Theory ST 1661.4:

Reliability and

Survival Analysis

ST 1661.5: Machine Learning

AUST 691.c: 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.

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