KARNATAK UNIVERSITY, DHARWAD
ACADEMIC (S&T) SECTION

ಕರ್ನಾಟಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಧಾರವಾಡ
ವಿದ್ಯಾಮಂಡಳ (ಎಸ್&ಟಿ) ವಿಭಾಗ

ಸ್ವಾತಂತ್ರ್ಯದ ಅಮೃತ ಮಹೋತ್ಸವ

Tele: 0836-2215224
e-mail: academic.st@kud.ac.in
Pavate Nagar,Dharwad-580003
ಪಾವಟಿ ನಗರ, ಧಾರವಾಡ – 580003

NAAC Accredited
'A' Grade 2014

website: kud.ac.in

No. KU/Aca(S&T)/JS/MGJ(Gen)/2024-25/ 1612 Date: 27 JUL 2024

ಅಧಿಸೂಚನೆ

ವಿಷಯ: ಸರಕಾರದ ಆದೇಶ ದಿನಾಂಕ: 08.05.2024 ಅನುಸಾರ 2024–25ನೇ ಶೈಕ್ಷಣಿಕ ಸಾಲಿನಿಂದ ಎಲ್ಲ ಸ್ನಾತಕ ಪದವಿಗಳಿಗೆ NEP ಅಡಿಯಲ್ಲಿ ಪ್ರೋಗ್ರಾಂ ವಿನ್ಯಾಸ (Curriculum Structure)ದಂತೆ ಪರಿಷ್ಕೃತ ಪಠ್ಯಕ್ರಮದ ಅನುಷ್ಠಾನ ಕುರಿತು.

ಉಲ್ಲೇಖ: 1. ಸರ್ಕಾರದ ಪ್ರಧಾನ ಕಾರ್ಯದರ್ಶಿಗಳು, ಉನ್ನತ ಶಿಕ್ಷಣ ಇಲಾಖೆ ಇವರ ಆದೇಶ ಸಂಖ್ಯೆ: ಇಡಿ 166 ಯುಎನ್ಇ 2023, ದಿ: 08.05.2024.

2. ವಿದ್ಯಾವಿಷಯಕ ಪರಿಷತ್ ಸಭೆಯ ನಿರ್ಣಯಗಳ ಸಂ:2, 3, 4, 5, 6, 7, 8 & 9, ದಿ:16.07.2024.

3. ಮಾನ್ಯ ಕುಲಪತಿಗಳ ಅನುಮೋದನೆ ದಿನಾಂಕ: 27/07/2024

ಮೇಲ್ಕಾಣಿಸಿದ ವಿಷಯ ಹಾಗೂ ಉಲ್ಲೇಖಗಳನ್ವಯ, ಉಲ್ಲೇಖ–01ರ ಸರಕಾರ ಆದೇಶಾನುಸಾರ 2024–25ನೇ ಶೈಕ್ಷಣಿಕ ಸಾಲಿನಿಂದ ಅನ್ವಯವಾಗುವಂತೆ, ಈ ಕೆಳಗಿನ ಎಲ್ಲ ಸ್ನಾತಕ ಪದವಿಗಳ NEP ಅಡಿಯ ಪ್ರೋಗ್ರಾಂ ವಿನ್ಯಾಸ (Curriculum Structure)ದಂತೆ ಪರಿಷ್ಕೃತ ಪಠ್ಯಕ್ರಮ ರಚನೆ ಕುರಿತಾಗಿ ಸಂಬಂಧಿಸಿದ ಅಭ್ಯಾಸಸೂಚಿ ಮಂಡಳಿ ಹಾಗೂ ನಿಕಾಯಗಳ ಶಿಫಾರಸ್ಸನಂತೆ ವಿದ್ಯಾವಿಷಯಕ ಪರಿಷತ್ ಸಭೆಯ ಅನುಮೋದಿತ ಪದವಿಗಳ ಪಠ್ಯಕ್ರಮಗಳನ್ನು ಕ.ವಿ.ವಿ. ಅಂತರ್ಜಾಲ www.kud.ac.in ದಲ್ಲಿ ಭಿತ್ತರಿಸಲಾಗಿದೆ. ಸದರ ಪಠ್ಯಕ್ರಮಗಳನ್ನು ಕ.ವಿ.ವಿ. ಅಂತರ್ಜಾಲದಿಂದ ಡೌನಲೋಡ ಮಾಡಿಕೊಳ್ಳಲು ಸೂಚಿಸುತ್ತ ವಿದ್ಯಾರ್ಥಿಗಳು ಹಾಗೂ ಸಂಬಂಧಿಸಿದ ಎಲ್ಲ ಬೋಧಕರ ಗಮನಕ್ಕೆ ತಂದು ಅದರಂತೆ ಕಾರ್ಯಪ್ರವೃತ್ತರಾಗಲು ಕ.ವಿ.ವಿ.ಯ ಎಲ್ಲ ಅಧೀನ ಹಾಗೂ ಸಂಲಗ್ನ ಮಹಾವಿದ್ಯಾಲಯಗಳ ಪ್ರಾಚಾರ್ಯರುಗಳಿಗೆ ಸೂಚಿಸಲಾಗಿದೆ.

ಅ.ನಂ.	ಪದವಿ				ಸೆಮಿಸ್ಟರ್
1	1	B.A	8	BTTM	1 ರಿಂದ 6ನೇ ಸೆಮಿಸ್ಟರ್
	2	BSW	9	B.Sc	
	3	B.Sc. (H.M)	10	BCA	
	4	B.Com	11	B.Com (CS)	
	5	B.Com (E-Commerce Operation)	12	B.Com (Retail Operations)	
	6	B.Com (Banking Financial Services & Insurance)	13	B.Com (Logistics)	
	7	BBA	14	BBA (Logistics Management)	
2	1	B.Sc (Data Science)	2	B.Sc (Artificial Intellgence & Machinery Learning)	1 ಮತ್ತು 2ನೇ ಸೆಮಿಸ್ಟರ್
3	1	BASLP	3	BPA	1 ರಿಂದ 8ನೇ ಸೆಮಿಸ್ಟರ್
	2	BVA	4	B.Sc. Pulp & Paper	

ಕುಲಸಚಿವರು.

ಅಡಕ: ಮೇಲಿನಂತೆ

ಗೆ,
ಕರ್ನಾಟಕ ವಿಶ್ವವಿದ್ಯಾಲಯದ ವ್ಯಾಪ್ತಿಯಲ್ಲಿ ಬರುವ ಎಲ್ಲ ಅಧೀನ ಹಾಗೂ ಸಂಲಗ್ನ ಮಹಾವಿದ್ಯಾಲಯಗಳ ಪ್ರಾಚಾರ್ಯರುಗಳಿಗೆ. (ಕ.ವಿ.ವಿ. ಅಂತರ್ಜಾಲ ಹಾಗೂ ಮಿಂಚಂಚೆ ಮೂಲಕ ಬಿತ್ತರಿಸಲಾಗುವುದು)

ಪ್ರತಿ:

1. ಕುಲಪತಿಗಳ ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು / ಕುಲಸಚಿವರ ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು / ಕುಲಸಚಿವರು (ಮೌಲ್ಯಮಾಪನ) ಆಪ್ತ ಕಾರ್ಯದರ್ಶಿಗಳು, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
2. ಅಧೀಕ್ಷಕರು, ಪ್ರಶ್ನೆ ಪತ್ರಿಕೆ / ಗೌಪ್ಯ / ಜೆ.ಎ.ಡಿ. / ವಿದ್ಯಾಂಡಳ (ಪಿ.ಜಿ.ಪಿಎಚ್.ಡಿ) ವಿಭಾಗ, ಸಂಬಂಧಿಸಿದ ಕೋರ್ಸುಗಳ ವಿಭಾಗಗಳು ಪರೀಕ್ಷಾ ವಿಭಾಗ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
3. ನಿರ್ದೇಶಕರು, ಕಾಲೇಜು ಅಭಿವೃದ್ಧಿ / ವಿದ್ಯಾರ್ಥಿ ಕಲ್ಯಾಣ ವಿಭಾಗ / , ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
4. ನೊಡಲ್ ಅಧಿಕಾರಿಗಳು, ಯು.ಯು.ಸಿ.ಎಂ.ಎಸ್. ಘಟಕ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.
5. ಎನ್.ಇ.ಪಿ. ನೊಡಲ್ ಅಧಿಕಾರಿಗಳು, ಸಿ.ಡಿ.ಸಿ. ವಿಭಾಗ, ಕ.ವಿ.ವಿ. ಧಾರವಾಡ.

KARNATAK UNIVERSITY, DHARWAD

B.Sc. (Statistics)

SYLLABUS

With Effect from 2024-25

DISCIPLINE SPECIFIC CORE COURSE (DSC) FOR SEM I -VI,

SKILLENHANCEMENTCOURSE (SEC) FOR SEMIV/V/VI and

ELECTIVE COURSES FOR SEM V AND VI

AS PER NE P (Revised):2024

Karnatak University, Dharwad

B.Sc. in Statistics

Effective from 2024-25

Sem.	Type of Course	Theory/ Practical	Course Code	Course Title	Instruction hour/ week	Total hours / sem	Duration Of Exam	Marks			Credits
								Formative	Summative	Total	
I	DSC-1	Theory	**C1STA1T1**	Descriptive Statistics and Elements of Probability	04hrs	60	03hrs	20	80	100	04
	DSC-2	Practical	**C1STA1P1**	Practicals based on **C1STA1T1**	04hrs	56	03hrs	10	40	50	02
II	DSC-3	Theory	**C2STA1T1**	Probability Distributions and R-Programming	04hrs	60	03hrs	20	80	100	04
	DSC-4	Practical	**C2STA1P1**	Practicals based on **C2STA1T1**	04hrs	56	03hrs	10	40	50	02
III	DSC-5	Theory	**C3STA1T1**	Theory of Sampling and Statistical Inference - I	04hrs	60	03hrs	20	80	100	04
	DSC-6	Practical	**C3STA1P1**	Practicals based on **C3STA1T1**	04hrs	56	03hrs	10	40	50	02
1V	DSC-7	Theory	**C4STA1T1**	Exact Sampling Distributions and Statistical Inference - II	04hrs	60	03hrs	20	80	100	04
	DSC-8	Practical	**C4STA1P1**	Practicals based on **C4STA1T1**	04hrs	56	03hrs	10	40	50	02
*V	DSC-9A	Theory	**C5STA2T1**	Statistical Quality Control and Reliability	04hrs	60	03hrs	20	80	100	04
	DSC-10A	Practical	**C5STA2P1**	Practicals based on **C5STA2T1**	04hrs	56	03hrs	10	40	50	02
	DSC-9B	Theory	**C5STA2T2**	Operations Research	04hrs	60	03hrs	20	80	100	04
	DSC-10B	Practical	**C5STA2P2**	Practicals based on **C5STA2T2**	04hrs	56	03hrs	10	40	50	02
*VI	DSC-11A	Theory-	**C6STA2T1**	Design of Experiments and Economic Statistics	04hrs	60	03hrs	20	80	100	04
	DSC-12A	Practical	**C6STA2P1**	Practicals based on **C6STA2T1**	04hrs	56	03hrs	10	40	50	02
	DSC-11B	Theory-	**C6STA2T2**	Econometrics and Demography	04hrs	60	03hrs	20	80	100	04
	DSC-12B	Practical	**C6STA2P2**	Practicals based on **C6STA2T2**	04hrs	56	03hrs	10	40	50	02
V	EC-1	Theory	**C5STA5T1**	Indian Official Statistics	03hrs	45	03hrs	20	80	100	03
VI	EC-2	Theory	**C6STA5T1**	Statistical Techniques for Research	03hrs	45	03hrs	20	80	100	03
IV/V/VI **	Skill	Practical	**C0STA6P1**	Data Science with R Programming	04hrs	56	03hrs	10	40	50	02

*student shall offer either DSC 9A and DSC10A or DSC 9B and DSC10B in 5th semester. Similarly, student shall offer either DSC 11A and DSC12A or DSC 11B and DSC12B in 6th semester.

** Student shall study Skill of this subject either in 4th / 5th / 6th but not in all the semester.

Karnatak University, Dharwad
B.Sc. Statistics

1. Programme Specific Outcomes (PSO):

On completion of the 03 years Degree in Statistics students will be able to:

PSO 1 : To Acquire knowledge of different topics of Statistics and ability to apply to relevant areas. Scientific problems, basic analysis and interpretation of data.

PSO 2 : To provide a foundation of Statistics principles and business practices for effectively using Data Science Techniques and enterprise software/packages.

PSO 3 : Be able to use modern scientific, engineering and IT tools or techniques such as use of Excel and R program tools for solving statistical problems related to the domain of interest.

PSO 4 : To specialize in Statistical Methods, Data Science, Machine Learning and its applications

PSO 5 : Be able to work effectively as an individual/ team member so as to build a multidisciplinary team.

PSO 6 : To cater the needs of managing the business application

PSO 7 : Be in a position to develop industrial applications

PSO 8 : Abide by the norms of professional ethics in respective disciplines

PSO 9 : Be able to communicate effectively with the stakeholders and give and receive clear instructions.

PSO 10 : Remains curious and enthusiastic in learning advanced knowledge in the respective discipline.

2. Eligibility and Admission criteria

1. The student who has taken Mathematics at Pre-University level or 12^{th} standard under CBSE syllabus or an equivalent course with Mathematics as one of the subjects.
2. The other rules for admission are as per the Government and University notifications from time to time**.**

B.Sc. Semester–I

Discipline Specific Course (DSC)-1

Course Title: Descriptive Statistics and Elements of Probability

Course Code: C1STA1T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-1	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Analyse the data by converting raw data into tabular form and presenting in the form of Diagrams.

CO2: Form the discrete and continuous frequency distribution and presenting in the form of different graphs.

CO3: Know performance of the variable/ attributes by using different measures of central tendency.

CO4: Understand the consistency and variability of a group and compare it with two or more groups

CO5: Establish the degree of relationship between two or more groups

CO6: Understand the cause and effect relationship between the variables and also understand forecasting of a variable

CO7: Know about the basics of probability theory.

Unit	**Title:** Descriptive Statistics and Elements of Probability	**60 hrs/ sem**
Unit I	**Introduction to Statistics:** Introduction, meaning, definition, functions, limitations and applications of statistics. Variable, attribute, types of variables, types of data: Quantitative data and Qualitative data, cross-sectional and time series, discrete and continuous. Scales of measurement: nominal, ordinal, interval, ratio. Formation of a uni-varaite and bi-variate frequency distribution, marginal and conditional distributions, relative frequency distributions, cumulative frequency distributions. Describing data with diagrams and graphs: One and two dimensional diagrams. Graphical presentation of a frequency distribution- Histogram, Frequency polygon, frequency curve and ogives.	15hrs
Unit II	**Univariate Data Analysis:** Describing data with averages: Measures of central tendency – Arithmetic mean, Geometric mean, Harmonic mean, Median & Mode. Definition, formulae, properties, merits and demerits. Describing positions: Measures of partition values – Quartiles, Deciles & Percentiles, definition, formulae. Describing Variability: Measures of dispersion – Absolute & relative measures, Range, Quartile Deviation, Mean Deviation and Standard Deviation, definition, formulae, properties, merits and demerits. Describing shape: Measures of Skewness: Meaning, need, types of skewness, absolute and relative measures. Measures of	15hrs

	Kurtosis: Need, types of kurtosis, measurement of kurtosis. Standard theoretical examples. Box Plots.	
Unit III	**Bi-variate and Multivariate Data Analysis:** Correlation: Definition, Types of correlation, Methods of measuring correlation, Scatter diagram, Karl Pearson's coefficient of linear correlation and its properties. Correlation Coefficient for qualitative data: Spearman's rank correlation coefficient and its properties. Simple linear regression analysis- regression equations by method of least squares, linear regression coefficients and its properties. Plane of regression and its derivation, estimation of a and b in case of three variables, partial regression coefficient, Residual, properties of residuals, Standard deviation of residuals, Multiple and partial correlation, definition, derivation and their standard properties.	15hrs
Unit IV	**Elements of Probability:** Basic concepts: Random experiment, Sample space, event, Mutually exclusive, exhaustive, equally likely events, complimentary events, independent and dependent events, definition of probability: Classical, Statistical and Axiomatic, Addition, Multiplication and Conditional probability theorems for any two events with proofs, theoretical examples. Bayes' theorem and its applications.	15hrs

Recommended books:

1. Bansilal & Arora, S.R.: Mathematics of Probability & Statistics, R. Chand & Co., New Delhi.
2. Chatterji, P.N.: Mathematical Statistics, Rajhans Prakashana Mandir, Educational Publishers, Meerut.
3. Goel, B.S., Satyaprakash and Roshan lal: Mathematical Statistics, Pragati Prakashana, Meerut.
4. Goon A.M., Gupta M.K. and Dasgupta B. : Basic Statistics.
5. Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics Volume I and II. The World Press Private Limited, Calcutta.
6. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
7. Kalyan Kumar Mukherjee: Probability and Statistics, New Central Book Agency (P) Ltd., Calcutta.
8. Ray & Sharma: Mathematical Statistics, Ram Prasad & Sons, Agra.
9. Robert V. Hogg and Allen T. Craig: Introduction to Mathematical Statistics (Fifth Edition), Pearson Education Inc, New Delhi.
10. Rohatgi, V.K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–I

Discipline Specific Course (DSC)

Course Title: Practicals based on **C1STA1T1**

Course Code: C1STA1P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-2	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1: Draw suitable Diagrams and Graphs.

CO2: Compute suitable measures of central tendency for a data

CO3: Compute suitable measures of dispersion.

CO4: Compute suitable measures of Skewness and Kurtosis.

CO5: Compute suitable correlation coefficient.

CO6: Understand the concepts of Multiple correlation and regression compute

CO7: Compute probabilities by using appropriate methods.

All the Practicals to be first solved manually then results should be executed using MS-Excel. The first practical is based on MS-Excel package. All the Practicals to be first solved manually then results should be verified using MS-Excel package.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

1. Formation of a frequency distribution: Uni-variate frequency distributions, cumulative frequency distributions and bi-variate frequency distributions.
2. Diagrammatic Representation of data
3. Graphical presentation of a frequency distribution.
4. Measures of Central Tendency- Mean and its properties, Weighted mean, Median, Mode, Geometric mean Harmonic mean and partition values.
5. Measures of Dispersion – Range, coefficient of range, Quartile deviation, coefficient of QD, Mean Deviation, coefficient of MD, Standard Deviation, Coefficient of Variation.
6. Problems on measures of Skewness and Kurtosis
7. Problems on Karl Pearson's and Spearman's correlation coefficient.
8. Simple Regression
9. Problems on Multiple and Partial correlations.
10. Problems on Multiple Regression.
11. Problems on Probability
12. Application of Bayes theorem.

B.Sc. Semester– II

Discipline Specific Course (DSC)-3

Course Title: Probability distributions and R-Programming

Course Code : C2STA1T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-3	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Understand the concept of random variable, Mathematical expectation and different generating functions.

CO2: Know the characteristics of different discrete probability distributions.

CO3: Understand the fitting of different discrete probability distributions

CO4: Know the characteristics of different Continuous probability distributions

CO5**:** Understand the fitting of different Continuous probability distributions.

CO6: Know the applications of different discrete and continuous probability distributions.

CO7: Understand the Oder statistics and introduction of R programming with some basic commands.

Unit	Title: Probability distributions and R-Programming	60 hrs/ sem
Unit I	**Random Variable and Mathematical Expectation:** Definition of a random variable, probability mass function, probability density function, distribution function and its properties. Joint distributions: Definition of joint distribution, Marginal and conditional distributions, joint probability functions, independence of random variables. Transformation of Random Variables and Jacobian of transformation with illustrations, Mathematical expectation of a random variable, Addition and Multiplication theorems on mathematical expectations, properties of expectation. Generating functions and their applications**:** Moments - raw and central moments and their interrelationships and properties, Moment generating functions, cumulants generating functions, probability generating functions, and their applications, theorems associated with MGF. Chebyshev's inequality.	15 hrs
Unit II	**Standard discrete distributions:** Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Hyper geometric distributions, definition, mean, variance, moments, moment generating functions, recurrence relation for probabilities and moments for binomial, Poisson, and Negative binomial distributions, additive property, cumulants generating function, theoretical examples.	15 hrs

Unit III	**Standard continuous distributions:** Rectangular, Normal, Beta, Gamma, and Exponential distributions, definitions through p.d.f's, Mean, variance, moments, recurrence relations, Additive property of exponential and gamma variates, Properties of Normal distribution and theoretical examples. Cauchy distribution. Transformation of variables.	15 hrs
Unit IV	**R-Programming :** Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open source philosophy. R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers. Standard functions, e.g., sin, cos, exp, log, etc. The different types of numbers in R: Division by zero leading to Infor -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c(), seq() and colon operator. How functions map over vectors. Functions to summarize a vector: sum, mean, sd, median etc. Extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting functions plot(), lines(), abline(). No details about the graphics parameters except colour and line width. Barplot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x). Problems on discrete and continuous probability distributions.	15hrs

Recommended books:

1. A.M. Mood and Graybill: Introduction to the theory of Statistics.
2. Bansilal & Arora, S.R.: Mathematics of Probability & Statistics, R. Chand & Co., New Delhi.
3. Chatterji, P.N.: Mathematical Statistics, Rajhans Prakashana Mandir, Educational Publishers, Meerut.
4. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
5. John E Freund: Mathematical Statistics (Sixth Edition), Pearson Education (India),New Delhi.
6. Mukhopadhaya, P. (1996). Mathematical Statistics. New Central Book Agency (P) Ltd., Calcutta.
7. R.V.Hogg, E. A.Tannis , Probability and Statistical Inference: Third Edition; Collier McMillan Publishers.
8. Robert V. Hogg and Allen T. Craig: Introduction to Mathematical Statistics (Fifth Edition), Pearson Education Inc, New Delhi.
9. Rohatgi, V.K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
10. Sundarapandian.V : Probability, Statistics and Queueing theory, PHI learning Private Limited, New Delhi.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–II

Discipline Specific Course (DSC)

Course Title: Practicals based on **C2STA1T1**

Course Code: C2STA1P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-4	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1 Calculate pmf, pdf, df, Mathematical expectation and different generating functions.

CO2: Calculate probability problems of different discrete probability distributions.

CO3: Fit the different discrete probability distributions

CO4: Calculate probability problems of different Continuous probability distributions

CO5: Fit the different Continuous probability distributions.

CO6: write R code for statistical tools covered in this paper.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

1. Demonstration of R functions to compute probabilities, cumulative probabilities, etc., for standard distributions.
2. Demonstration of MASS R package fitting standard distributions and use of the fitdistrplus R package for the same.
3. Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation.
4. Transformation of discrete & continuous random variables.
5. Problems on Mathematical Expectation.
6. Problems on Moments.
7. Application problems based on Standard Discrete Distributions-Binomial, Poisson, Negative Binomial.
8. Application problems based on Discrete Distributions-Geometric, Hyper-Geometric.
9. Fitting Standard Discrete Distributions: Binomial, Poisson, Geometric and Negative Binomial.
10. Application problems based on Standard continuous distributions.
11. To find the ordinate for a given area for normal distribution and Problems based on area property of normal distribution and Application problems based on Normal Distribution.
12. Fitting of Standard Continuous Distributions distribution.

B.Sc. Semester–III

Discipline Specific Course (DSC)-5

Course Title: Theory of Sampling and Statistical Inference - I

Course Code: C3STA1T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-5	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs):At the end of the course students will be able to:

CO1 : Understand the principles underlying sampling as a means of making inferences about a population.

CO2 : Understand the difference between probability and nonprobability sampling.

CO3 : Understand different sampling techniques.

CO4 : To learn to estimate population parameters from a sample.

CO5:To find estimators using different methods of estimation and compare estimators.

CO 6: To carryout statistical inference using different tests of hypotheses under different scenarios.

CO6: To carryout the interval estimation to know the probable range of the parameters.

Unit	Title: Theory of Sampling and Statistical Inference – I	60 hrs/ sem
Unit I	**Introduction to Sampling, and Simple Random Sampling:** Concept of population and sample. Need for sampling, Complete Enumeration versus Sample Surveys, Merits and Demerits, Non – Probability and Probability Sampling, Need and illustrations. Use of random numbers, Principal steps in sample survey. Requisites of a good questionnaire. Pilot surveys, Sampling and non – sampling errors, Description of SRS, simple random sampling according to with and without replacement procedures, Unbiased estimates of population mean and totals, Derivation of sampling variances, standard errors of estimators, Simple random sampling for proportions, derivation of variances of estimators and their estimation, determination of sample size for estimation of population mean and population proportion, Merits and demerits of Simple random sampling.	15 hrs
Unit II	**Stratified sampling and systematic sampling** : Stratification and its benefits; basis of stratification, Technique, estimates of population mean and total, variances of these estimates, proportional, optimum allocations, Neyman's allocation, allocation with cost functions and their comparison with SRS. Practical difficulties in allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Linear	15 hrs

	systematic sampling Technique; estimates of population mean and total, variances of these estimates (N=n x k). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.	
Unit III	**Point Estimation:** Concepts of the terms: Parameter, Estimator, Estimate and Standard Error of an estimator. Unbiasedness, Mean squared error as a criterion for comparing estimators. Relative efficiency, Most efficient estimator, Minimum variance unbiased estimator (MVUE). Consistency: Definition and criteria for consistency. Proof of Sufficient condition for consistency using Chebyshev's inequality. Sufficient statistic, Fisher – Neyman criterion and Neyman–Factorization theorem (without proof), Measure of information – Fisher information function. Cramer–Rao inequality (with proof) and its applications in the construction of minimum variance unbiased estimators. Methods of Estimation: Maximum Likelihood and Moment estimation methods. Standard examples from theoretical distributions, Illustration for non uniqueness of MLE's. Properties of ML Estimator and MM Estimator. Examples illustrating properties of MLE.	15 hrs
Unit IV	**Order Statistics :** Definition of ordered statistic and their distributions, Derivation of first order statistic, highest order statistic, r^{th} order statistics, joint distribution of order statistics and their derivations, simple examples to obtain the distributions of order statistics,). **Interval Estimation:** Meaning of confidence interval and pivotal quantity, Confidence interval based on pivotal quantity. Confidence coefficient. Confidence intervals for mean, difference between means for large and small samples, Confidence intervals for variance and ratio of variances under normality. Large sample confidence intervals for proportion and difference between two proportions and correlation coefficient.	15hrs

Recommended books:

1. Cochran, W.G. (1977). Sampling Techniques. Wiley Eastern Ltd., New Delhi.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics Volume I and II. The World Press Private Limited, Calcutta.
3. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
4. Gupta, S.C.: Fundamentals of Statistics, Himalaya Publishing House, Bombay.
5. Kalyan Kumar Mukherjee: Probability and Statistics, New Central Book Agency (P) Ltd., Calcutta.
6. Lindgren: Introduction to Probability & Statistics, MacMillan Publishers.
7. Mukhopadhaya, P. (1996). Mathematical Statistics. New Central Book Agency (P) Ltd., Calcutta.
8. R.V.Hogg, E. A.Tannis, Probability and Statistical Inference: Third Edition; Collier McMillan Publishers.
9. Robert V. Hogg and Allen T. Craig: Introduction to Mathematical Statistics (Fifth Edition), Pearson Education Inc, New Delhi.
10. Rohatgi, V. K and Saleh, A.K.MD. (2001). *An Introduction to Probability and Statistics*, 2nd edition. John Wiley & Sons, Inc., New York.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester– III

Discipline Specific Course (DSC)-6

Course Title: Practicals based on **C3STA1T1**

Course Code: C3STA1P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-6	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1 : Estimate the population total, population mean and estimate of variance of the estimates using Simple random sampling.

CO2 : Estimate the population total, population mean and estimate of variance of the estimates using Stratified Random sampling.

CO3 : Estimate the population total, population mean and estimate of variance of the estimates using Systematic sampling.

CO4 :Comparison of mean square error of the estimate.

CO5: Calculate the estimators using different methods of estimation and compare estimators.

CO6: Calculate the confidence interval for means, variance and proportions.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

The first practical is based on become skilled at R-programming using package. Practicals 2 to 13 have to be first solved manually then results should be verified using R-programming.

1. Demonstration of essential R functions and R packages for application of sampling and estimation theory.
2. To select a simple random sampling with and without replacement procedure from a finite population sing Random Number Tables.
3. Problems on Simple Random Sampling.
4. Problems on Stratified Random Sampling.
5. Problems on Systematic Random Sampling.
6. Computation of mean square errors of estimators and comparison.
7. Problems on Maximum Likelihood Estimation.
8. Problems on Maximum Likelihood Estimation by Analytical Method.
9. Problems on Method of Moment Estimation.
10. Construction of Confidence Intervals for single mean and difference of two means.
11. Construction of Confidence Intervals for single proportion and difference of two proportions.
12. Construction of Confidence Intervals – for single variance and ratio of two variances.

B.Sc. Semester–IV

Discipline Specific Course (DSC)-7

Course Title: Exact Sampling Distributions and Statistical Inference - II

Course Code: C4STA1T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-7	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Study exact sampling distributions and their applications.

CO2: Carryout statistical inference using different tests of hypotheses under different scenarios.

CO3: Learn about MLR property and Likelihood ratio tests.

CO4 : Explore about sequential inference.

CO5 : Learn about one sample and two sample nonparametric tests.

Unit	Title: Exact Sampling Distributions and Statistical Inference - II	60 hrs/ sem
Unit I	**Chi-Square, t and F Sampling Distributions**: Chi-square Distribution: Definition, Derivation of Chi-distribution by Moment Generating Function method, Properties, Moments, Recurrence relation for moments about origin and mean, limiting form of Chi- distribution. Independence of sample mean and sample variance in random sampling from a normal distribution, Theoretical examples, Definition of students t – variate and Fisher's t – variate, Derivation of students t – distribution, Moments and Recurrence relation for t – distribution, Limiting form of t – distribution, Theoretical examples. Snedecor's F – distribution: Definition, Derivation of F - distribution, Properties, Moments and recurrence relation for moments, Inter relationship between t, F and χ^2 distributions, Theoretical examples.	15 hrs
Unit II	**Tests of Significance and Testing of Hypothesis**: Definitions of some important terms: Statistical Hypothesis, Simple & Composite, Null and Alternative hypothesis, Critical Region, Type I and Type II errors, Level of Significance, Power function and Power of the test, One tailed and Two tailed tests, Z test, Large sample test for mean and difference of means, Proportion and difference of proportions. Applications of χ^2 , t and F distributions, Definitions of Most powerful test, Uniformly most powerful test. Statement and proof of Neyman - Pearson Lemma and its use in the construction of most powerful test, Standard examples for computation of Type I and Type II errors and Power of the test. Standard examples for NP lemma to determine most powerful Critical Region for one sided and two sided alternatives, and for Power Curves. Idea of randomized and non – randomized tests and critical function.	15 hrs

Unit III	**Likelihood Ratio Test & MLR property**: Likelihood ratio tests (LRT). Large sample approximations to the distribution of the likelihood ratio statistics (without proof). LRT for single mean for normal case (large and small samples). Definition of a monotone likelihood ratio property, verification of the property for some standard distributions for existence of one sided UMP tests. **Sequential Testing**: Need for sequential tests, Wald's SPRT, Graphical procedure of SPRT, Determination of stopping bounds, Construction of SPRT of strength (α, β) for Binomial, Poisson, Normal and Exponential distributions. Approximate expressions for OC and AS N functions for Binomial, Poisson and Normal distributions. Difference between SPRT and NP-test. Merits and demerits of SPRT.	15 hrs
Unit IV	**Non –Parametric tests**: Need for Non-Parametric Tests, Advantages and Dis-advantage of non-parametric methods over parametric methods. Assumptions in non-parametric methods. Sign test for quantiles, Sign test based on paired observations, Wilcoxon signed rank test for one sample and paired samples. Comparison of the sign-test and Wilcoxon signed– rank test, Kolmogorov – Smirnov one-sample test, Comparison of it with chi-square test, Wald-Wolfowitz runs test, Median test and Mann-Whitney-Wilcoxon –test for two sample problems, Run test for randomness, Test for independence based on Spearman's rank correlation coefficient.	15hrs

Recommended books:

1. Abraham Wald: Sequential Analysis, John Wiley & Sons, New York.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B.: Fundamentals of Statistics Volume I and II. The World Press Private Limited, Calcutta.
3. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
4. Randles, R.H. and Wolfe, D.A.: Introduction to the Theory of Non-parametric Statistics, John Wiley & Sons, New York.
5. Ray & Sharma: Mathematical Statistics, Ram Prasad & Sons, Agra.
6. Robert V. Hogg and Allen T. Craig: Introduction to Mathematical Statistics (Fifth Edition), Pearson Education Inc, New Delhi.
7. Rohatgi, V.K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
8. Sidney Siegel: Non parametric Statistics, for behavioral sciences, International Student Edition, McGraw Hill Ltd, India.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–IV

Discipline Specific Course (DSC)

Course Title: Practicals based on **C4STA1T1**

Course Code: C4STA1P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-8	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1: Calculate the test of significance for small samples.

CO2: Calculate test of significance for large samples.

CO3: Calculate probability of Type I and Type II errors and drawing power curves.

CO4 : Carry out the SPRT for different distributions.

CO5 :Calculate one sample and two sample nonparametric tests.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

1. Demonstration of essential R functions and R packages for application of Testing of Statistical Hypothesis.
2. Applications of Chi-square distribution-test for variance and independence of attributes and Goodness of fit.
3. Applications of Students t – distribution.
4. Applications of Snedecor's F – distribution
5. Large Sample Tests for mean and difference of means.
6. Large Sample Tests for proportion and difference of proportions.
7. Testing of Statistical Hypothesis - I– Problems on computation of Type I , Type II errors and power function.
8. Testing of Statistical Hypothesis -II–Computation of Most powerful tests and Power curves.
9. Sequential Probability Ratio Test for discrete distribution.
10. Sequential Probability Ratio Test for continuous distribution.
11. Non – Parametric Tests for single sample (sign test, wilcoxon signed rank test), Randomness test, Kolmogorov-Smirnov goodness of fit.
12. Non – Parametric Tests for two independent samples(sign test, wilcoxon signed rank test ,median test, wilcoxon mann-whitney test), Run test, Rank Correlation Coefficient.

B.Sc. Semester–V

Discipline Specific Course (DSC)-9A

Student shall select DSC 9A & 10 A or 9B & 10 B for 06 credits only

Course Title:-Statistical Quality Control and Reliability

Course Code: C5STA2T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-9A	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Understand the concept of quality and its management, including quality planning, control, and improvement.

CO2: Recognize the contributions of quality pioneers and understand the different types of quality costs.

CO3: Know about Define statistical quality control (SQC), its aims, and objectives.

CO4: Develop the skills to apply various quality control techniques, understand the importance of quality management, and utilize control charts to monitor and improve quality in real-world industrial scenarios.

CO5: Students will develop the necessary skills to apply control chart techniques effectively in real-world quality control scenarios.

CO6: Understand the concept of Reliability Theory.

CO7: Understand concept of System Reliability.

Unit	**Title: Statistical Quality Control and Reliability**	**60 hrs/ sem**
Unit I	**Introduction to Statistical Quality Control:** Concept of quality and its management - quality planning, quality control and quality improvement, quality pioneers, quality costs. Meaning, aims and objectives of statistical quality control. Concept of variations and its impact, chance & assignable causes of variation. Relevance of exploratory data analysis, run plot, lag plot, frequency distribution and other QC tools. Statistical quality control, Process control, Product control, Importance & uses of statistical quality control in industry. Introduction to control charts.	15 hrs
Unit II	**Control charts for variables:** Theoretical basis and practical background of control charts for variables. 3σ - Control Limits, Warning limits and Probability limits. Derivation of control limits and construction of $\overline{X}$ & R charts and $\overline{X}$ & S charts and interpretation. Criteria for detecting lack of control. Rational subgroups, group control charts and sloping control charts, Natural tolerance limits and specification limits, Process capability studies.	15 hrs

Unit III	**Control charts for attributes:** Theoretical basis and practical background of control charts for attributes. Fraction defective p-chart, number of defectives np-chart, number of defects per unit C – chart, and U – chart, derivation of control limits and interpretations.	15 hrs
Unit IV	**Reliability:** Definitions of Reliability Theory, reliability function, failure rate (hazard rate), cumulative failure rate. Distributions useful in modeling the life length (Exponential, Weibull, Gamma, Pareto). Monotone failure rates, Classes of life Distributions (IFR, IFRA, NBU, NBUE, DMRL) and their geometric characterization. **System Reliability:** Series System, Parallel System and Standby Redundant System in case of exponential distributions.	15 hrs

Recommended books:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Volume I and II. The World Press Private Limited, Calcutta.
2. Grant, E.L. and Richard S. Leavenworth: Statistical Quality Control, McGraw-Hill Book Company Inc., New York.
3. Gupta, R.C.: Statistical Quality Control, Khanna Publishers, New Delhi.
4. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.
5. Gupta, S.C.: Fundamentals of Statistics, Himalaya Publishing House, Bombay.
6. Jerry Banks: Quality Control, John Wiley Pub. New York.
7. Mahajan, M: Statistical Quality Control, Dhanpat Rai & Co. Ltd. New Delhi.
8. Montgomery Douglas C.: Introduction to Statistical Quality Control, John Wiley & Sons, Inc. (Wiley Student Edition).
9. S. K. Sinha and B. K. Kale, Life Testing & Reliability, Wiley Eastern, New Delhi 1990.
10. S. K. Sinha, Life Testing & Reliability Estimation, John Wiley & Sons, 1980.
11. Trivedi K. S., Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI, 1997.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–V

Discipline Specific Course (DSC)-10A

Course Title: Practicals based on **C5STA2T1**

Course Code: C5STA2P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-10A	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Construct various control charts and become skilled in R-Programming.

CO2: Construct control chart for variables.

CO3: Construct group and sloping control charts.

CO4: Construct control chart for attributes.

CO5: Calculate reliability function, Hazard rate for different distributions.

CO6: Calculate reliability function for different systems.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

Practicals based on **Statistical Quality Control and Reliability theory** using R-programming.

The first three practicals are based on become skilled at R-programming using package *qicharts for constructing control charts* and acquire skill for *constructing control charts* using any others packages developed in R or other software's.

Practicals 4 to 12 has to be first solved manually and then results should be verified using R-programming.

1. Demonstration of R-programming packages which are essential for constructing control charts *in particular qichart package*.
2. Demonstration of R-programming packages for constructing control charts *(qcc package, etc.)*.
3. Exploratory data analysis, run plot, lag plot, frequency distribution and other QC tools for detecting lack of control.
4. Construction and interpretation of statistical control charts for Variables, X-bar & R-chart.
5. Construction and interpretation of statistical control charts for Variables, X-bar & S-chart.
6. Construction and interpretation of group control charts.
7. Construction and interpretation of sloping control charts.
8. Construction and interpretation of natural tolerance limits and specification limits, Process capability studies.
9. Construction and interpretation of statistical control charts for attributes, np-chart, and p-chart.
10. Construction and interpretation of statistical control charts for attributes, c-chart and u-chart.
11. Computation and interpretation of reliability function, failure rate (hazard rate), cumulative failure rate, etc.
12. Computation and interpretation of system reliability, failure rate (hazard rate), and cumulative failure rate, etc.

B.Sc. Semester–V

Discipline Specific Course (DSC)-9B

Student shall select DSC 9B & 10 B or DSC 9A & 10 A for 06 credits only

Course Title: Operations Research

Course Code: **C5STA2T2**

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-9B	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Understand the origin, development and scope of O R.

CO2: Find the solution of L.P.P by different methods.

CO3: Understand and solve the TP and AP and also its applications.

CO4: Know the types of games and their solutions by different methods.

CO5: Know the types of Inventory models and solutions.

CO6: Understand the types of sequencing problems and to solve them.

Unit	Title: Operations Research	60 hrs/ sem
Unit I	**Introduction to operations research and LPP:** Introduction, Meaning, and definition of operation research, phases of O.R., O.R. Models, Scope of O.R., Linear Programming Problem: Definition of general linear programming problem, Basic concepts, and formulation of LPP, Graphical solution, Simplex method of solving an LPP, Slack, Surplus and Artificial variables, Charne's M- technique of solving LPP, Two phase simplex method with illustrations, Concept of Duality of an LPP, Conversion of Standard Primal and Dual problems and vice versa.	15 hrs
Unit II	**Transportation Problem & Assignment Problem:** Definition, mathematical model, balanced and unbalanced TP, Methods of obtaining Initial basic feasible solution: North West corner rule, Lowest Cost Entry Method, Vogel's Approximation Method (VAM), Test for optimality by MODI method, Determination of optimal solution with illustrations. **Assignment problem**: definition, mathematical model, balanced and unbalanced assignment problem, maximization and minimization problems under assignment, Hungarian method of solving an AP with illustrations, Distinction between Transportation Problem & Assignment Problem.	15 hrs

Unit III	**Game theory:** Introduction, two person zero sum games, Pure and mixed strategies, maximin and minimax principle, games with saddle point and without saddle points, solution of 2x2 games with mixed strategies, rectangular games, 2xn and mx2 graphical method of solving game problems, dominance rule, matrix oddments method for 3x3 games.	15 hrs
Unit IV	**Inventory Theory:** Description of an inventory system, inventory cost, demand and lead time, EOQ model with and without shortages, EOQ model with finite replenishment, Probabilistic demand, News paper boy problem. **Sequencing problems:** Principle assumptions, Johnson's procedure for determining an optimal sequence, Problems of two machines and 'n' jobs, Three machines and 'n' jobs reducible to two machines and 'n' jobs, calculation of total elapsed time and idle time, Traveling Salesman problem and its solution.	15hrs

Recommended books:

1. Churchman, C.W., Ackoff, R.L., and Arnoff, E.L.: Introduction to Operations Research, John Wiley Pub.
2. Dr. Goel, B.S. and Dr. Mittal, S.K.: Operations Research, Pragati Prakashan, Meerut.
3. Frederick S. Hillier &Gerals J. Liberman: Introduction to Operations Research (Eighth Edition), Tata
4. Gupta, P.K. and Hira, D.S.: Operations Research, S. Chand & Company Ltd., New Delhi.
5. Gupta, R.K.: Operations Research, Krishna Prakashana Mandir, Meerut.
6. Kanti Swarup, Gupta, P.K. and Man Mohan: Operations Research, Sultan Chand & Sons, New Delhi.
7. Kapoor, V.K.: Operations Research Problems & Solutions, Sultan Chand & Sons, New Delhi.
8. Kapoor, V.K: Operations Research, Sultan Chand & Sons, New Delhi.
   McGraw-Hill Publishing Company Limited, New Delhi.
9. Mustafi, C.K.: Operations Research Methods and Practice, New Age Pub. New Delhi.
   New York.
10. Sharma, S.D.: Operations Research, Kedarnath Ramnath & Co. Publishers, Meerut.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester– V

Discipline Specific Course (DSC)-10B

Course Title: Practicals based on **C5STA2T2**

Course Code: C5STA2P2

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-10B	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1: Solve the L.P.P by method in theory paper.

CO2: Solve the TP by method in theory paper.

CO3: Solve the AP by method in theory paper.

CO4: Solve the problems on games by method in theory paper.

CO5: Solve the Inventory problems.

CO6: Solve the sequencing problems.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

Practicals based on **OPERATIONS RESEARCH** using R-programming and other OR software's.

The first two practicals are based on become skilled at using R-programming using package *lpSolve for solving* LLP, TP and AP and acquire skill to solve LLP, TP and AP using any one of free optimization software's (e.g. GAMS, AMPL, TORA, WINQSB/LINGO LINDO).

Practicals 3 to 12 has to be first solve manually then results should be verified using R-programming and others software's.

1. Demonstration of R-programming package *lpSolve for solving* LLP, TP and AP.
2. Demonstration of other free optimization software's (e.g. GAMS, AMPL, TORA, LINDO).
3. Formulation and solution of LPP using Graphical method - I
4. Solution of LPP using Graphical method - II
5. Solving LPP using Simplex algorithm.
6. Solving LPP using Charn's Big-M method and Two Phase method.
7. Determination of optimal solution of Transportation Problem using MODI method (Use Initial Basic feasible solution obtained from North West corner rule, Lowest Cost Entry and Vogel's Approximation (VAM) Methods).
8. Determination of optimal solution of Assignment Problem using Hungarian method.
9. Solving Game Theory Problems (Problems based on game matrix and Mixed strategy)
10. Graphical solution to mx2 / 2xn rectangular games
11. Solving Inventory Problems.
12. Solving Sequencing Problems.

B.Sc. Semester–VI

Discipline Specific Course (DSC)-11A

Student shall select DSC 11A& 12 A or DSC 11B& 12B for 06 credits only

Course Title: Design of Experiments and Economic Statistics

Course Code: C6STA2T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-11A	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Understand one-way and two-way classified data in ANOVA.

CO2 : Understand different designs (CRD, RBD, LSD) and missing plot techniques on RBD and LSD.

CO3 : Understand the different factorial experiments.

CO4: Know the application of Index Numbers.

CO5: Understand the consumer price Index Numbers and its application.

CO6: Study the different components of time series for estimating and forecasting of a phenomenon.

Unit	Title: Design of Experiments and Economic Statistics	60 hrs/ sem
Unit I	**Analysis of variance:** Definition, Chance and Assignable causes of variation, object of analysis of variance, basic assumptions, Analysis of variance for one way, two way classified data with one observation per cell (fixed effect models only), Statement of linear model, assumptions in the model, splitting the sum of squares in to various component parts, expected mean squares of various sums of squares, preparation of ANOVA tables, least significant difference, Two way classified data with interaction, case of multiple but equal number of observations per cell in two-way classification, linear mathematical model, splitting sum of squares, expectation of various sums of squares, ANOVA table, interpretations.	15 hrs
Unit II	**Design of Experiments:** Meaning, Important terms used in designs of experiments. Basic principles: Randomization, Replication and Local Control. Completely randomized design, Randomized block design and Latin Square designs – layout, models, least square estimates of parameters, hypothesis, test procedures and ANOVA tables. Merits and Demerits of the designs studied, Efficiency of design. Missing plot technique for RBD and LSD – Estimation of single missing observation. **Factorial Experiments:** Need for factorial experiments, 2^2 and 2^3 factorial experiments,	15 hrs

	Main effects and Interaction effects, their best estimates, idea of contrasts, orthogonal contrasts, Yates' method of computing factorial effect totals.	
Unit III	**Index Numbers** : Definition, Problems involved in the construction of index numbers, methods of constructing index numbers of prices and quantities, simple aggregative and price relatives method, weighted aggregative and weighted average of relatives method, important types of weighted index numbers: Laspeyre's, Paasche's, Bowley's, Marshall-Edgeworth, Fisher's, method of obtaining price and quantity index numbers, tests consistency of index numbers, time reversal test, factor reversal test, and Circular test for index numbers, Uses and limitations of index numbers. Consumer price index number: Problems involved in the construction of cost of living index number, advantages and disadvantages, Aggregative expenditure method and Family budget method for the construction of consumer price index numbers. Applications of Cost of Living Index numbers.	15 hrs
Unit IV	**Time Series Analysis :**Introduction, definition and components of Time series, illustrations, Additive, Multiplicative and mixed models, analysis of time series, methods of studying components of time series : method of moving averages, least squares method – linear, quadratic, exponential trend fittings to the data. Seasonal variation - definition, illustrations, measurements by simple average method, ratio to moving average method, ratio to trend method & link relatives method, Cyclical variation-definition, distinction from seasonal variation, Irregular variation- definition, illustrations.	15hrs

Recommended books:

1. Das M.N. and Giri, N: Design of Experiments, Theory and Applications, Wiley Eastern Ltd. New Delhi.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Volume I and II. The World Press Private Limited, Calcutta.
3. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.
4. Gupta, S.C.: Fundamentals of Statistics, Himalaya Publishing House, Bombay.
5. Montgomery, D.C.: Design and Analysis of Experiments, John Wiley & Sons, New York.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester– VI

Discipline Specific Course (DSC)-12A

Course Title- Practicals based on **C6STA2T1**

Course Code: C6STA2P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-12A	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1: Carryout analysis of one-way and two-way classified data in ANOVA.

CO2 : Carryout analysis of different designs - CRD, RBD, LSD and missing plot techniques.

CO3 : Carryout analysis of different factorial experiments.

CO4: Calculate Index Numbers.

CO5: Calculate the consumer price Index Numbers.

CO6: Calculate secular trend by the method of least squares.

CO7: Calculate seasonal indices by different methods.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

Practicals based on **Design of experiments and Economic Statistics** using R-programming

Practicals 2 to 12 has to be first solve manually then results should be verified using R-programming and others software's

1. Demonstration of R-programming packages which are essential for the analysis of Design of experiments and Analysis of Economic Statistics.
2. One way Analysis of Variance
3. Two way Analysis of Variance
4. Completely Randomized Design
5. Randomized Block Design
6. Latin Square Designs
7. Missing Plot Technique for RBD & LSD, Analysis of Factorial Experiments
8. Calculate Index Number by Simple aggregative and Price relative method.
9. Laspeyre's, Paasche's, Bowley's, Marshall- Edgeworth and Fisher'sPrice and Quantity Index Numbers
10. Cost of living Index Numbers
11. Time Series : Secular Trend Estimation (Fitting of linear, quadratic and exponential trend)
12. Time Series : Measurement of seasonal Indices (ratio to moving average method, ratio to trend method, link relative method)

B.Sc. Semester– VI

Discipline Specific Course (DSC)-11B

Student shall select DSC 11A& 12 A or DSC 11B& 12B for 06 credits only

Course Title: Econometrics and Demography.

Course Code: C6STA2T2

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-11B	**Theory**	**04**	**04**	**60hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Study the simple linear regression model for estimation of regression coefficients.

CO2: Study the multiple linear regression model for estimation of regression coefficients.

CO3: Understand the different sources of National and International demographic data.

CO4: Study the different measures of mortality and their policies.

CO5: Study the different measures of Fertility.

CO6: Study the reproductive rates.

CO7: Estimate the expectation of life through life tables.

Unit	Title: Econometrics and Demography.	60 hrs/ sem
Unit I	**Introduction to Econometrics and Simple Linear Regression :** Definition and scope of econometrics, Relationship between econometrics, mathematical economics and Statistics, goals of econometrics, limitations. Simple linear regression model, role of disturbance term in the model, ordinary least square method (OLS), Statistical assumptions, desirable small sample properties of least square estimators, Large sample properties of estimators, Linearity, unbiasedness, minimum variance property, Sampling distribution of least square estimators.	15 hrs
Unit II	**Multiple Linear Regression**: Introduction of Multiple Linear Regression model, Relation between simple and multiple regression coefficients, Model with two explanatory variables, statistical properties of the least squares estimates of multiple linear regression model with two explanatory variables – Linearity, Unbiasedness and sampling variance. Test of significance of parameter estimates. The General Linear regression model, Matrix Approach to linear regression model, statistical properties of	15 hrs

	the estimates. Regression Analysis and Analysis of Variance, Concepts of analysis of variance, comparison between Regression Analysis and Analysis of Variance, test based on Analysis of Variance.	
Unit III	**Measures of Mortality:** Sources of demographic data, measurement of mortality, crude death rate, specific death rates, and standardized death rates, infant mortality rate, maternal mortality rate, neo natal mortality rates, merits and demerits and comparisons of various mortality rates.	15 hrs
Unit IV	**Measures of Fertility :** Fecundity, fertility, measurement of fertility, crude birth rate, general fertility rate, age specific fertility rate and total fertility rates, merits and demerits of each measure of fertility, comparative study of these measures of fertility, Growth rates: Gross reproduction rate and Net reproduction rates, their definition, distinctions, merits and demerits. **Life tables :** Components of a life table, force of mortality and expectation of life, construction of life tables, relationship between various components of a life table, derivation of appropriate formulae for components, complete life table, Uses of life tables.	15hrs

Recommended books:

1. Companies Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
2. G.M.K. Madanani (1980) : Introduction to Econometrics, second edition, Oxford & IBH Publishing company, New Delhi.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Volume I and II. The World Press Private Limited, Calcutta.
4. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition McGraw Hill
5. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.
6. Gupta, S.C.: Fundamentals of Statistics, Himalaya Publishing House, Bombay.
7. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–VI

Discipline Specific Course (DSC)-12B

Course Title: Practicals based on **C6STA2T2**

Course Code: C6STA2P2

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
DSC-12B	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1: Estimate the regression coefficients in simple linear regression model.

CO2: Estimate the regression coefficients in multiple linear regression model.

CO3: Calculate the different measures of mortality.

CO4: Calculate the different measures of Fertility.

CO6: Calculate different reproductive rates.

CO7: construct the life tables.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

Practicals based on **Econometrics and Demography** theory using R-programming.
Practicals 2 to 12 has to be first solve manually then results should be verified using R-programming and others software's.

1. Demonstration of R-programming packages which are essential for the analysis of Econometrics and Demography
2. Estimation parameters of simple linear regression model by Method of ordinary least squares.
3. Estimation of residuals and coefficient of determination.
4. Estimation parameters of Multiple linear regression model by Method of ordinary least squares.
5. Problem related to Analysis of variance in Multiple regression model.
6. Problems on testing of regression coefficient.
7. Measures Mortality-I
8. Measures Mortality-II
9. Measures Fertility-I
10. Measures Fertility-II
11. Gross and Net reproduction rates.
12. Life tables.

B.Sc. Semester– V

Elective Course (EC)-1

It is for other combination students

Course Title:-Indian Official Statistics

Course Code: C5STA5T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
EC-1	**Theory**	**03**	**04**	**45hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Understand official statistical system in India and their functions.

CO2 : Understand the census operations and characteristics available in census data.

CO3: Study the collection of census data by different methods.

CO4: Know the different sample survey organizations and their functions in India.

CO5: Fit different growth model for time series data.

Unit	Title: Indian Official Statistics	45 hrs/ sem
Unit I	**National Population Census:** Definition of National Population census, official system in India for census enumeration. Reference point of time. Methods of collecting census data - Household method, Canvasser method and Mailed questionnaire method, their merits & demerits. Framing of census questionnaire. **Census Survey:** Methods of conducting census survey. De-facto method and D-jure method, their merits and demerits. Distinction between D-facto and D-jure methods of conducting census. Functions and aims of census. Changes introduced in the house schedule of 2001 and 2011 census.	15 hrs
Unit II	**Central Statistical Organization (CSO):** Central Statistical Organization : Department of Statistics, Ministry of Statistics and Programme Implementation, Central Statistical Organization (CSO)- functions of CSO, divisions of CSO, advantages and limitations of the organization. **National Sample Survey Organization (NSSO**): Introductions of National Sample Survey Organization, functions and working of NSSO, Advantages and dis-advantages of NSSO data.	15 hrs

Unit III	**Sources of Data :** Various Secondary sources of population statistics –Various data from World Bank www.worldbank.org, World Health Organization-www.who.int, Population Reference Bereau-www.prb.org, Asian development Bank- www.adb.org and Various organizations. Reserve Bank of India – www.rbi.org.in. **Population growth models** – exponential, logarithmic, Gompertz and logistic models.	15 hrs

Recommended books:

1. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Volume I and II. The World Press Private Limited, Calcutta.
3. Gupta, S.C.: Fundamentals of Statistics, Himalaya Publishing House, Bombay.
4. Gupta C. B.,(2004) Introduction to Statistical Mehods, Vikas Publishing House, PVT. Ltd,
5. Gupta S. P., Statistical Methods, Sultan Chand and sons, New Delhi

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester– VI

Elective Course (EC)-2

Course Title: Statistical Techniques for Research

Course Code: C6STA5T1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
EC-2	**Theory**	**03**	**04**	**45hrs.**	**3hrs.**	**20**	**80**	**100**

Course Outcomes (COs): At the end of the course students will be able to:

CO1: Know the preliminaries and methods of data collection.

CO2: Understand the objectives and hypothesis for research.

CO3: Analyse the data with different statistical tools.

CO4: Write report of the research.

Unit	Title: Statistical Techniques for Research	45 hrs/ sem
Unit I	**Introduction to Research Methods** What is Research? Role of Research in important areas. Characteristics of Scientific Method. Process of research: Stating Hypothesis or Research question, Concepts & Constructs, Units of analysis & characteristics of interest, Independent and Dependent variables, Extraneous or Confounding variables. Measurements and scales of Measurements. Types of research: Qualitative & Quantitative Research, Longitudinal Research, Survey & Experimental Research.	15 hrs
Unit II	**Data Collection** Survey Methodology and Data Collection, sampling frames and determination of sample size. Pilot survey, check for validity and consistency of questionnaire or schedule. **Statistical Tools for research analysis** Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.	15 hrs
Unit III	**Drafting of Questionnaire and Report writing** Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), questions and answers in	15 hrs

	surveys, Internal & External validity, interpret the results and draw inferences. Formats and presentations of Reports – an overview.	

Recommended books:

1. Kothari, C.R. (2004): Research Methodology: Methods and Techniques, 2nd Revised Edition, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications.

Formative Assessment for Theory	
Assessment Occasion/type	**Marks**
InternalAssessmentTest1	05
InternalAssessmentTest2	05
Assignment	10
Total	**20Marks**
Formative Assessment as per guidelines.	

B.Sc. Semester–IV/ V/VI

Skill Enhancement Course (SEC)

Student shall study SEC in any one of the Semesters either in IV or V or VI semester

College shall decide to allot the students

Course Title: Practical- Machine Learning with R-programming

Course Code: C0STA6P1

Type of Course	Theory /Practical	Credits	Instruction hour per week	Total No. of Lectures/Hours /Semester	Duration of Exam	Formative Assessment Marks	Summative Assessment Marks	Total Marks
SEC	**Practical**	**02**	**04**	**56hrs.**	**3hrs.**	**10**	**40**	**50**

Course Outcomes (COs): At the end of the course, students will be able to:

CO1 : Develop an appreciation for what is involved in Learning models from data

CO2 : Understand a wide variety of learning algorithms

CO3 : Understand how to evaluate models generated from data

CO4 : Apply the algorithms to a real problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

List of the Experiments, each will have 4rs / Week (Minimum 12 experiments)

1. Machine Learning Algorithms using Simple Linear Regression Model (Problem 1)
2. Machine Learning Algorithms using Simple Linear Regression Model (Problem 2)
3. Machine Learning Algorithms using Multiple Linear Regression Model (Problem 1)
4. Machine Learning Algorithms using Multiple Linear Regression Model (Problem 2)
5. Machine Learning Algorithms using Polynomial Regression Model (Problem 1)
6. Machine Learning Algorithms using Polynomial Regression Model (Problem 2)
7. Machine Learning Algorithms using Logistic Regression Model (Problem 1)
8. Machine Learning Algorithms using Logistic Regression Model (Problem 2)
9. Machine Learning Algorithms using Logit Transformation Model (Problem 1)
10. Machine Learning Algorithms using Logit Transformation Model (Problem 2)
11. Machine Learning Algorithms using Decision Tree Learning Methods(Problem 1)
12. Machine Learning Algorithms using Decision Tree Learning Methods(Problem 2)

Books recommended:

1. Andreas M and Guido S (O'Reilly) (2016). Introduction to machine learning with Python.
2. Deborah Nolan and Duncan Temple Lang (2015). Data Science in R- A case studies approach to computational reasoning and problem solving, CRC Press.
3. Gareth J, Daniel W, Trevor, H and Tibshirani, R (2013). An Introduction to Statistical Learning with Application in R.
4. Nina Zumel and John Mount (2020), Practical Data Science With R, Second Edition, Manning Shelter Island.
5. Zelterman , D. (2015). Applied Multivariate Statistics with R, Springer.

Instruction for Theory Paper :

1. Theory course shall carry 100 marks of which 80 marks allotted for semester end examination and 20 marks for internal assessment.
2. The semester end examination will be conduction by the university which will be of three hours duration and maximum 80 marks. The minimum passing marks in the examination is of 40 percent.
3. There shall be three sections in every question paper- A, B and C. Section A shall have 12 question of each 2 marks and candidates have to solve 10 questions (10x2 = 20 marks). Section B shall have 8 questions of each 5 marks and the candidate has to solve 6 questions only (6x5 = 30 marks). Section C shall have 6 questions of each 10 marks and the candidate has to solve 3 questions as per instructions (3x10 = 30 marks).

B.Sc. programme: 2024-25

GENERAL PATTERN OF **THEORY** QUESTION COURSE FOR DSC/ EC

(80 marks for semester end Examination with 3 hrs duration)

Part-A

1. Question number 1-10 carries 2 marks each. : 20 marks

Part-B

2. Question number 11- 18 carries 05Marks each. Answer any 06 questions : 30 marks

Part-C

3. Question number 19-22 carries 10 Marks each. Answer any 03 questions : 30 marks

(Minimum 1 question from each unit and 10 marks question may have sub questions for 7+3 or 6+4 or 5+5 if necessary)

Total: 80 Marks

Note: Proportionate weight age shall be given to each unit based on number of hours Prescribed