Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Program Structure

Semester-III

Course Code	Course Name	Teaching Hours		Credits Assigned		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
GNKUSSTAMJ1103/ GNKUSSTAMJ1P103	(Major) Paper-I (**Probability Distributions**)	45	30	3	1	4
GNKUSSTAMJ2103/ GNKUSSTAMJ2P103	(Major) Paper-II **(Theory of Sampling)**	45	30	3	1	4
GNKUSSTAMI103/ GNKUSSTAMIP103	(Minor) Paper **(Data Analysis Using R)**	45	30	3	1	4
GNKUSSTAVSC103	Vocational Skill Course (VSC) **(Operations Research Techniques)**	--	60	--	2	2
	Open Elective (OE)	30	-	2	-	2
GNKUSSTAAEC103	Ability Enhancement Course (AEC)	30	--	2	--	2
	Co-curricular (CC)	--	--	--	--	2
	On job training (OJT)/ Field project (FP)/Research project (RP)/ Community engagement & service (CEP)	--	--	--	--	2
Total		**195**	**150**	**13**	**05**	**22**

Semester-IV

Course Code	Course Name	Teaching Hours		Credits Assigned		
		Theory	**Practical**	**Theory**	**Practical**	**Total**
GNKUSSTAMJ1104/ GNKUSSTAMJ1P104	(Major) Paper-I **(Probability and Sampling Distributions)**	45	30	3	1	4
GNKUSSTAMJ2104/ GNKUSSTAMJ2P104	(Major) Paper-II **(ANOVA and Design of Experiments)**	45	30	3	1	4
GNKUSSTAMI104/ GNKUSSTAMIP104	(Minor) Paper **(Operations Research Techniques)**	45	30	3	1	4
GNKUSSTASEC104	Skill Enhancement Course (SEC) **(Statistical Analysis Using R)**	--	60	--	2	2
	Open Elective (OE)	30	-	2	-	2
GNKUSSTAAEC104	Ability Enhancement Course (AEC)	30	--	2	--	2
	Co-curricular (CC)	--	--	--	--	2
	On job training (OJT)/ Field project (FP)/Research project (RP)/ Community engagement & service (CEP)	--	--	--	--	2
Total		**195**	**150**	**13**	**05**	**22**

G N KHALSA COLLEGE OF ARTS, SCIENCE & COMMERCE(AUTONOMOUS), MATUNGA, MUMBAI-400019

MOTTO

Essence of Wisdom is Service to Humanity

VISION

To emerge as a Centre of Excellence in Higher Education.

MISSION

To create strong analytical minds with scientific temper, fostering global competencies through the spirit of humanism thereby bringing about holistic development of the students by remaining in sync with the teachings of Guru Nanak Dev Ji.

QUALITY POLICY

To attain excellence in all our endeavours namely teaching, research and continuing education; adopt self-evaluation as a measure for continuous improvement and ensure accountability.

Based on the provided motto, vision, mission, and quality policy, program outcomes for a Science program of our college are:

Undergraduate Science Program Outcomes:

PO1	**Foundational Understanding:** Develop a foundational understanding of core scientific principles and theories across various disciplines of science.
PO2	**Analytical Skills:** Develop analytical and problem-solving skills to critically analyse scientific problems and apply scientific methodologies.
PO3	**Global Perspective:** Gain a global perspective by understanding diverse scientific issues and incorporating ethical considerations in scientific practices.
PO4	**Research Awareness:** Gain awareness of research methodologies and techniques, preparing for future research endeavours.
PO5	**Holistic Development:** Experience holistic development by embracing values of humanism, empathy, and social responsibility in scientific pursuits.
PO6	**Communication Skills:** Enhance communication skills to effectively convey scientific concepts to diverse audiences.
PO7	**Continuous Learning:** Develop a commitment to lifelong learning and staying updated with advancements in science.
PO8	**Ethical Practices:** Understand and adhere to ethical standards in scientific research and practice.

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Programme: B.Sc. Statistics

Programme Specific Outcomes (PSOs) for B.Sc. in Statistics

Sr. No.	A student completing B.Sc. in Statistics will be able to:
PSO 1	Acquire core knowledge of the basic concepts of statistics which include the major areas of probability distributions, statistical inference, survey sampling, designs of experiments, non- parametric inference, and operations research.
PSO 2	Apply the concepts of statistics, Operations Research, Probability theory, Time Series, Designs of Experiment, etc. in real life problems.
PSO 3	Practical exercises done will enable students to analyse and interpret data and to draw valid conclusions. This will enable students to face real time applications.
PSO 4	Understand the applications of statistics concept in other disciplines such as mathematics, physics, economics, etc.
PSO 5	Compute statistical measures using software and programs.
PSO 6	Acquire skills to write competitive examinations and get opportunities for job placements in various sectors
PSO 7	Provides a platform for pursuing higher studies leading to Postgraduate or Doctorate degrees.

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester III

Major-I

Name of the paper: Probability Distributions

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: SY B.Sc. STATISTICS
Semester-III: Major-I
Course Title: Probability Distributions
Course Code: GNKUSSTAMJ1103
Credits: 3
No of lectures (Hours): 45
Marks: 75 (60:40)

Course Objectives:

Sr. No.	Course objectives
The aim of this course is to gain the ability to analyse, predict, and make decisions in situations where randomness or variability plays a role. This understanding is fundamental in various fields such as statistics, machine learning, finance, physics, and many others, where uncertainty is a constant factor. **The course aims at:**	
1.	Computing M.G.F, C.G.F and characteristics function for discrete probability distributions.
2.	Learning Binomial, Poisson, Geometric, Negative Binomial and Hyper geometric distribution along with its properties and their application.
3.	Understating bivariate e probability distribution and its properties
4.	Obtaining joint, marginal and conditional distribution of two-dimensional random variables.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Calculate and recognise the main characteristics of the discrete probability distribution though MGF, CGF and characteristics function.	1	2, 3	U, Ap &E
CO 2	Understand how a discrete random variable follows a particular probability model.	1, 2	1	U, R & Ap

CO 3	Explain the formal definition of a joint probability mass function of two discrete random variables.	1	1, 4	An & Ap
CO 4	Demonstrate marginal probability mass function from joint probability mass function from the joint probability mass function or joint probability density function.	2, 4	3	Ap, An & E

SY BSc SEM III Syllabus

Major-Paper I (Probability Distributions)

Unit I	**Univariate Discrete and Continuous Random Variables**	**15**	CO Mapping
1.1	**Moment Generating Function:** Definition, Properties: Effect of change of origin and scale. M.G.F of sum of two independent random variables X and Y, Extension of this property for n independent random variables and for n i.i.d. random variables. All above properties with proof, Uniqueness Property without proof. Raw moments using M.G.F: using expansion method and using derivative method.	**05**	CO1
1.2	**Cumulant generating Function**-Definition, Properties: Effect of change and origin and scale, Additive Property of C.G.F. and cumulants Both properties with proof. Obtaining Cumulants using C.G.F. Derivation of relationship between moments and cumulants upto order four. Characteristic Function: Definition and properties (without Proof), Examples of obtaining raw moments and central moments up to order four using M.G.F. and C.G.F. for continuous and discrete distributions. Degenerate distribution (One point distribution) P(X=c), Mean, Variance, Use of Degenerate distribution.	**05**	CO1
1.3	**Discrete Uniform distribution.** Mean, Variance, coefficient of skewness using m.g.f., Bernoulli distribution. Mean, Variance, coefficient of skewness using m.g.f. **Binomial distribution:** Mean, Variance, Measures of skewness and Kurtosis based on moments using M.G.F. and C.G.F., Nature of probability curve, Mode, Additive property, If X follows Binomial, then to find distribution of n-X. Recurrence relation for moments with proof, Relation between Bernoulli and Binomial using m.g.f. Transformation of random Variable (Univariate) : examples based on it. Real life examples of Binomial distribution.	**05**	CO2
Unit 2	**M.G.F. & C.G.F. of Standard Discrete Distributions**	**15**	
2.1	**Poisson Distribution:** Mean, Variance, Measures of skewness and Kurtosis based on moments using M.G.F. and C.G.F., Nature of probability distribution with change in the values of parameters, Mode, Additive property. Recurrence relation for moments with	**05**	CO2

	proof for μ' r+1, μr+1. If X and Y are two independent Poisson variables Conditional distribution of X given X+Y with proof, Poisson distribution as limiting distribution of Binomial (with proof), Real life examples of Poisson distribution.		
2.2	**Geometric Distribution:** Definition in terms of No. of failures and No. of trials. Mean, Variance, M.G.F., Mean and Variance using M.G.F., C.G.F., Mean and Variance, μ3, μ4 using C.G.F., Coefficients of skewness and kurtosis and nature of the probability distribution. Lack of memory property with proof. If X and Y are two i.i.d. Geometric variables; Conditional distribution of X given X+Y with proof. Distribution of sum of k i.i.d. Geometric variables. **Negative Binomial Distribution:** Definition, Mean, Variance, M.G.F., Mean and Variance using M.G.F., C.G.F., Recurrence relation for central moments, Mean, Variance, μ3, μ4 using C.G.F., Coefficients of skewness and Kurtosis and nature of probability distribution. Lack of Memory property with proof. Recurrence relation for probabilities, Fitting of distribution. Limiting distribution of Negative Binomial distribution (with proof).	**05**	CO2
2.3	**Hyper geometric Distribution:** Definition, Mean, Variance, Limiting distribution of Hyper geometric distribution (with proof),If X and Y are two independent Binomial variables Conditional distribution of X given X+Y (with proof) **Truncated distribution:** Definition, Truncated Binomial and Truncated Poisson Distribution:(truncated at 0), Probability mass function, mean and variance. Real life situations of Geometric, Negative Binomial and Hypergeometric distributions.	**05**	CO2
Unit 3	**Bivariate Probability Distributions**	**15**	
3.1	**Two dimensional Discrete random variables:** Joint Probability mass function and its properties, Distribution function of (X, Y) and its properties, Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables, Marginal and conditional probability distributions. Conditional expectation, conditional variance.	**05**	CO3
3.2	**Continuous bivariate random variables:** Joint Probability density function and its properties, Distribution function of (X, Y) and its properties, Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables.	**05**	CO4
3.3	**Marginal and conditional probability distributions** -Conditional expectation, conditional variance - Regression Function. Transformation of Random Variables and Jacobian of transformation with illustrations.	**05**	CO4

References:

1. Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.(1957)
2. Introduction to Mathematical Statistics: R.V. Hogg, A.T. Craig; Fourth Edition; Collier , McMillan Publishers.(2005)
3. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Eighth Edition; Pearson Education Inc.(2014)
4. Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.(2016)
5. Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand &Sons, Tenth edition (2000)

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- **Combined passing of 40% with minimum 20% in Internal Component.**

Course: SY B.Sc. Statistics Practical
Semester-III: Major Paper-I
Course Title: Practical on Probability Distributions
Course Code: GNKUSSTAMJ1P103
Credits: 01
No of Practical (Hours): 30
Marks: 25 (60:40)

Sr. No.	Course objectives
The course aims at:	
1.	Computing M.G.F, C.G.F and characteristics function for discrete probability distributions.
2.	Investigating properties of Binomial, Poisson, Geometric, Negative Binomial and Hyper geometric distribution.
3.	Learning how to fit Binominal, Poisson, geometric and negative binomial models.
4.	Finding marginal and conditional distribution from bivariate distributions.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Calculate the main characteristics of the discrete probability distribution though MGF, CGF and Characteristics function.	1	2, 3	U, Ap
CO 2	Solve problems related to Discrete Uniform, Bernoulli, Binomial and Poisson Distribution.	2	1	E
CO 3	Solve problems related to Geometric, Negative Binomial and Hypergeometric Distribution.	2	1	E
CO 4	Learn how to use a joint probability mass function to find the probability of a specific event, to learn how to find a marginal probability mass function of a discrete and continuous random variables from the joint probability mass function or joint pdf	1, 2	3, 4	U, E
CO 5	Learn how to find distribution of transformed random variables for discrete and continuous cases	3	3	U, An & E

Sr No	List of practical
Probability Distribution	
1	Moment Generating Function, Moments.
2	Cumulant generating Function, Cumulants, Characteristic function.
3	Discrete Uniform.
4	Bernoulli, Binomial Distribution.
5	Poisson Distribution.
6	Geometric Distribution.
7	Negative Binomial Distribution.
8	Hypergeometric Distribution.
9	Fitting of Binomial and Poisson Distribution.
10	Fitting of Geometric, Negative Binomial Distribution.
11	Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation.
12	Transformation of discrete & continuous random variables.

References:

1. Introduction to the theory of statistics: A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company.(1957)
2. Introduction to Mathematical Statistics: R.V. Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.(2005)
3. Probability and Statistical Inference: R.V. Hogg, E. A. Tannis, Forth Edition; Collier McMillan Publishers.(2001)
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Eighth Edition; Pearson Education Inc.(2014)
5. Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand &Sons, Tenth edition (2000)

Examination:

External Practical Examination: 25 Marks

Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester III

Major -II

Name of the paper: Theory of Sampling

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Course: SY B.Sc. STATISTICS
Semester-III: Major Paper-II
Course Title: Theory of Sampling
Course Code: GNKUSSTAMJ2103
Credits: 3
No of lectures (Hours): 45
Marks: 75 (60:40)

Course Objectives:

Sr. No.	Course objectives
This section of the course aim at to learn how to select representative samples from a larger population in such a way that accurately reflects the characteristics of that population under investigation. **The course aims at:**	
1.	Learning data collection through questionnaire or schedule.
2.	Discussing different sampling methods: Learn about various techniques such as non-random sampling techniques and random sampling techniques.
3.	Understand how to select samples that accurately represent the characteristics of the larger population.
4.	Understanding Sampling and Non-Sampling errors
5.	Gain skills to estimate population parameters based on sample data, allowing for generalizations about the population.
6.	Learning how to determine required sample size of estimating parameters of the population under desire accuracy.
7.	To learn ratio and regression method of estimation under simple random sampling.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Apply basic concept of terminology which generally used in sample surveys.	1	1	U
CO 2	Develop questionnaire for sample surveys	1, 2	3	U & Ap
CO 3	Determine required sample size for estimating parameter of his /her subject of enquiry using Simple Random Sampling	3	3, 4	U & E
CO 4	Estimate parameters if Simple Random Sampling method is adopted.	2	2	U & Ap
CO 5	Explain stratified random sampling method and estimate the parameters under this method.	1	1, 2	Ap & E
CO 6	Explain ratio and regression method of estimation of parameters under investigation and their area of application.	1, 3	1, 2	Ap & E

SY BSc SEM III Syllabus

Major Paper II (Theory of Sampling)

Unit 1	**Concepts of Sampling and Simple Random Sampling**	15	CO Mapping
1.1	Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator, Bias, Unbiased Mean square error and Standard error. Census survey, Sample Survey. Steps in conducting sample survey with examples on designing appropriate Questionnaire.	**05**	CO1& CO2
1.2	Concepts of Sampling and Non-sampling errors. NSSO, CSO and their functions. Concepts and methods of Probability and Non-Probability Sampling. **Simple Random Sampling: (SRS):** Definition, Sampling with and without replacement (WR/WOR). Lottery method and use of Random numbers to select simple random sample. Estimation of population mean and population total.	**05**	CO1 & CO4
1.3	Expectation and Variance of the estimators, Unbiased estimator of variance of these estimators. (WR/WOR). Estimation of population proportion. Estimation of sample size based on a desired accuracy in case of SRS for variables and attributes. (WR/WOR).	**05**	CO 4 & CO 3
Unit 2	**Stratified Random Sampling**	**15**	CO Mapping
2.1	Need for Stratification of population with suitable examples. Stratified Random Sampling: Definition and its advantages.	05	CO4
2.2	Stratified Random Sampling method, Estimation of population mean and population total in case of Stratified Random Sampling (WOR within each stratum). Expectation and Variance of the unbiased estimators, Unbiased estimators of variances of these estimators	**05**	CO4 & CO5
2.3	Proportional allocation, Optimum allocation with and without varying costs. Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation and Neyman allocation	**05**	CO4 & CO5
Unit 3	**Ratio and Regression Estimation Method**	**15**	
3.1	**Ratio and Regression Estimation assuming SRSWOR:** Ratio Estimators for population Ratio, Mean and Total. Expectation and Mean Square Error of the Estimators. Estimators of Mean Square Error. Uses of Ratio Estimator	**05**	CO6
3.2	Regression Estimators for population mean and population total. Expectation and Variance of the Estimators assuming known value of regression coefficient ‘b’. Estimation of ‘b’.	**05**	CO6

	Resulting variance of the estimators. Uses of regression Estimator. Comparison of Ratio, Regression and mean per Unit estimators.		
3.3	Systematic sampling, Cluster sampling and Two Stage Sampling, Introduction, and its application.	**05**	CO6

References:

1. Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley. (1978)
2. Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
3. Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968)
4. Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V.Sukhatme; 3rd Edition; Iowa State University Press. (1984)
5. Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons. (2001)

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- **Combined passing of 40% with minimum 20% in Internal Component.**

SYBSc: Statistics Practical

Semester III: Major Paper -II

Course Title: Practical on Theory of Sampling

Paper Code: GNKUSSTAMJ2P103

Credits: 01

No. of Hours: 30

Marks: 25(60:40)

Sr. No.	Course objectives
This section of the course aim at to learn how to design questionnaire to collect data from sample surveys. They will be able to know how the parameters of the population are estimated in various random sampling methods. **The course aims at:**	
1	Learning data collection through questionnaire or schedule.
2	Understanding different sampling methods: Learn about various techniques such as non-random sampling techniques and random sampling techniques.
3	Applying how to select samples that accurately represent the characteristics of the larger population.
4	Understanding Sampling and Non-Sampling errors
5	Gaining skills to estimate population parameters based on sample data, allowing for generalizations about the population.
6	Learning how to determine required sample size of estimating parameters of the population under desire accuracy.
7	Learning ratio and regression method of estimation under simple random sampling.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Develop questionnaire for the survey for enquiry.	1	1	U & Ap
CO 2	Understand the difference between complete enumeration and sample survey.	1, 2	1,3	U & An
CO 3	Apply the idea of simple random sampling in daily life data. Understand selection of simple random sample.	3, 4	1, 4	An & Ap
CO 4	Estimating parameter of his /her subject of enquiry when he/ she is applying Simple and Stratified Random Sampling.	1, 2	3	Ap & E
CO 5	Have good knowledge of ratio and regression method of estimation and their area of application by solving problems in the practical's.	1, 2	3, 4	U, Ap & E

Sr No	List of practical
	Theory of Sampling
1	Designing of Questionnaire.
2	Survey on designed Questionnaire.
3	Sampling distribution.
4	Simple Random Sampling for Variables.
5	Simple Random Sampling for Attributes.
6	Estimation of Sample Size in Simple Random Sampling.
7	Comparison between SRSWR and SRSWOR.
8	Stratified Random sampling and Problem based on proportional allocation.
9	Stratified Random Sampling and Problem based on optimum allocation.
10	Comparison between proportional and optimum allocations with SRSWOR.
11	Ratio Estimation.
12	Regression Estimation.

References:

1. Sampling Techniques: W.G. Cochran; 3rd Edition; Wiley. (1978)
2. Sampling Theory and methods: M.N. Murthy; Statistical Publishing Society. (1967)
3. Sampling Theory: Des Raj; McGraw Hill Series in Probability and Statistics. (1968)
4. Sampling Theory of Surveys with Applications: P.V. Sukhatme and B.V.Sukhatme; 3rd Edition; Iowa State University Press. (1984)
5. Fundamentals of Applied Statistics: S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons. (2001)

Examination:

External Practical Examination: 25 Marks
Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science / Arts

Syllabus

Course: SY B.Sc. Mathematics / SY B.A. Economics

Semester III

Minor

Name of the paper: Data Analysis Using R

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: SY B.Sc. / SY BA.
Semester-III: Minor Paper
Course Title: Data Analysis Using R
Course Code: GNKUSSTAMI103 / GNKUASTAMI103
Credits: 3
No of lectures (Hours): 45
Marks: 100 (75:25)

Course Objectives:

Sr. No.	Course objectives
The course aims at:	
1	Introducing R, Loading, installing, and building packages.
2	To make students exercise the fundamentals of statistical analysis in R environment.
3	To analysis data for the purpose of exploration using Descriptive and Inferential Statistics.
4	To understand Probability and Sampling Distributions
5	Creative application of Linear Regression in multivariate context for predictive purpose.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Understand the fundamentals, standards of Functions and capabilities of R Language.	1	1	U, Ap & An
CO 2	Learning the basic R-Language Constructs	1	1	Ap, C
CO 3	Demonstrate Simulation in R-Language, Math functions and files processing	2	1, 2	U, E, An
CO 4	Know the Principals of Graphics performing hypothesis testing	1, 2, 3	1, 4	R, Ap & An
CO 5	Understand Correlation and Regression to analyse the underlying relationships between different variables.	2, 3	4	U, C, Ap & An

SY BSc / SY BA SEM III Minor Syllabus
Minor Paper (Data Analysis Using R)

Unit I	**Introduction to R programming and Data Visualization**	**15**	CO Mapping
1.1	**Introduction to R programming:** What is R?, Installing R and R Studio, R Studio Overview, Working in the Console, Arithmetic Operators, Logical Operations, Using Functions. Getting Help in R and Quitting R Studio, Installing and loading packages.	**05**	CO 1
1.2	**Data structures, variables, and data types in R:** Creating Variables- Numeric, Character and Logical, Data Vector, Data Frames, Factors, Sorting Numeric, Character, and Factor Vectors, Special Values.	**05**	CO 1, CO 2
1.3	**Data Visualization using ggplot2 library:** Scatter Plots, Box Plots, Scatter Plots and Box-and-Whisker Plots Together, Customize plot axes, labels, add legends, and add colours.	**05**	CO2
Unit 2	**Descriptive statistics and Testing of Hypothesis**	**15**	
2.1	**Descriptive statistics**: Measures of central tendency, Measures of variability, Skewness and kurtosis, Summary functions, describe functions, and descriptive statistics by group.	**05**	CO3
2.2	**Large sample Test using ggstatsplot library:** 1. Testing for population mean. 2. Testing for difference between two population means. 3. Testing for population proportion. 4. Testing for difference between two population proportions.	**05**	CO 4
2.3	**Analysis of variance using ggstatsplot library:** 1. One-way ANOVA 2. Two-way ANOVA **Chi square test using ggstatsplot library:** test for goodness of fit.	**05**	CO 4
Unit 3	**Probability distribution and Predictive Analysis**	**15**	
3.1	**Evaluating probabilities of standard distribution and plotting of graph of pmf and cdf:** 1. Binomial distribution 2. Poisson distribution 3. Hypergeometric distribution 4. Uniform distribution 5. Exponential distribution 6. Normal distribution	**05**	CO 5
3.2	**Generation of random sample and fitting of standard distributions:** 1. Binomial distribution 2. Poisson distribution	**05**	CO 5

	3. Hypergeometric distribution 4. Uniform distribution 5. Exponential distribution 6. Normal distribution		
3.3	**Predictive Analysis:** 1. Correlation and simple regression. 2. Analysis of simple time series data and fitting various mathematical curve: (i) Quadratic (ii) Power curve (iii) Exponential curve	**05**	CO 5

References:

1. R Cookbook, PaulTeetor, Oreilly: R Cookbook [R CKBK] [Paperback] R Cookbook [RKBK] [Paperback]Mar 31, 2011 by Paul Teetor.
2. R in Action,Rob Kabacoff, Manning: R in Action: Data Analysis and Graphics with RNov 5, 2018 | Unabridged by Robert Kabacoff and Dale Ogden.
3. Michael Akritas, " Probability & Statistics with R for Engineers and Scientists", 2nd Edition on, CRC Press, 2016.

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- **Combined passing of 40% with minimum 20% in Internal Component.**

Course: SY B.Sc. / SY B.A. Practical Minor
Semester-III: Minor Paper
Course Title: Practical on Data Analysis Using R
Course Code: GNKUSSTAMIP103 / GNKUASTAMIP103
Credits: 01
No of Practical (Hours): 30
Marks: 25 (60:40)

Course Objectives:

Sr. No.	Course objectives
The course aims at:	
1	How to use different functions in R, how to read data into R, accessing R packages, writing R functions, debugging, and organizing data using R functions.
2	Gives an idea to collect, compile and visualize data using statistical functions
3	To analysis data for the purpose of exploration using Descriptive and Inferential Statistics.
4	To understand Probability and Sampling Distributions
5	Creative application of Linear Regression in multivariate context for predictive purpose.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Access online resources for R and import new function packages into the R workspace	1	1	U & C
CO 2	Import, review, manipulate and summarize datasets in R	1	1	C
CO 3	Create and edit visualizations with R	2	1, 2	C, E, An
CO 4	Explore datasets to create testable hypotheses and identify appropriate statistical tests	1, 2, 3	1, 4	R, Ap & An
CO 5	Fitting various standard probability distribution	2, 3	4	E & Ap
CO 6	Correlation and Regression to analyse the underlying relationships between different variables.	1, 3	1, 2	E, C, Ap

List of Practical's:

Sr No	**List of practical experiments**
1	Fundamental of R
2	Implement different data structures in R (Vectors, Lists, Data Frames).
3	Visualization of data with different charts.
4	Summarizing various measure of descriptive statistics.
5	Testing of hypothesis for large sample test.
6	Analysis of variance and chi square test.

7	Evaluating probabilities of standard distribution and plotting of graph of pmf and cdf.
8	Generation of random sample and fitting of standard distributions.
9	Correlation and simple regression.
10	Fitting various mathematical curves.
11	Case study on summarizing the descriptive statistics.
12	Case study on reviewing inferential statistics.

References:

1. R Cookbook, PaulTeetor, Oreilly: R Cookbook [R CKBK] [Paperback] R Cookbook [RKBK] [Paperback]Mar 31, 2011 by Paul Teetor.
2. R in Action,Rob Kabacoff, Manning: R in Action: Data Analysis and Graphics with R, Nov 5, 2018 | Unabridged by Robert Kabacoff and Dale Ogden.
3. Michael Akritas, " Probability & Statistics with R for Engineers and Scientists", 2nd Edition on, CRC Press, 2016.

Examination:

External Practical Examination: 25 Marks
Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester III

Vocational Skill Course (VSC)

Name of the paper: Operation Research Techniques

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: SY B.Sc. Statistics
Semester – III: Vocational Skill Course (VSC)
Course Title: Operation Research Techniques
Course Code: GNKUSSTAVSC103
Credits: 2 (Practical based)
No of Practical Hours: 60
Marks: 50

Course Objectives:

Sr. No.	Course objectives
The main aim of this course is to develop the ability to find the best possible solution to a problem from a set of feasible alternatives. This involves maximizing or minimizing an objective function under certain constraints and uncertainties. studying the process of making economic and managerial decisions; analysing situations requiring decisions; studying simple and complex decision-making methods. **The course aims at:**	
1	To use quantitative methods and techniques for effective decisions–making
2	To help the students to understand the various techniques of solving problems
3	To know and use the various decision-making tools used in business.
4	To understand the basics of one-to-one assignment problems and job sequencing.
5	To apply decision-making methods and technologies for various forms of organizational and management tasks

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Comprehend the techniques and applications of optimization.	1, 2	1	R, Ap
CO 2	Analyse characteristics of a general linear programming problem	2	2, 3	R, Ap
CO 3	Interpret the transportation models' solutions and infer solutions to the real-world problems.	3	1, 3	R, An
CO 4	Recognize and solve assignment problems.	1, 2	2, 3	Ap, E, C
CO 5	Evaluate Total Elapsed time for processing of jobs.	2	2, 3	R & E
CO 6	Develop decision-making process of selected business from managerial, organizational, technological.	1, 2	1, 2 & 3	Ap, E, C

	List of Practical on Operation Research Techniques	No. Of hours	CO Mapping
Pract 1	**Mathematical Formulation of Linear Programming Problem and solving by Graphical Method**		
Content	Introduction to OR, Meaning and scope, models in OR. Requirements, Assumptions, Applications, Advantages and Limitations. Mathematical Formulation of LPP Model.Obtaining Optimal Solution for Linear Programming Problem (LPP)- Graphical Method.	05	CO 1
Pract 2	**Solving Linear programming problem for three variables: Simplex method**		
Content	Solution for more than two variables: Simplex Method for Type of LPP and for Slack Variable, Case - Maximization Function	05	CO 2
Pract 3	**Solving Linear programming problem for three variables: Big M method**		
Content	Solution for more than two variables: Introduction to surplus variable, artificial Variable, Case- Minimization Function	05	CO 2
Pract 4	**Duality: The Primal Vs- Dual Solutions.**		
Content	Concept of Duality: Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.	05	CO 2
Pract 5	**Transportation Problem: To obtain IBFS for Balanced and Unbalanced Problem**		
Content	Introduction to the problem, LP formulation of a transportation problem. Initial Basic feasible solution by north-west corner method, least cost method, and Vogel's approximation method.	05	CO 3
Pract 6	**Transportation Problem: To obtain Optimal solution using MODI method**		
Content	Finding Optimal Solution by Modified Distribution (MODI) Method. (u, v and Δ) after IBFS.	05	CO 3
Pract 7	**Assignment Problem using Hungarian method**		
Content	Mathematical Formulation. Comparison with Transportation Model. Hungarian Method. Unbalanced Assignment problems.	05	CO 4
Pract 8	**Sequencing Problem**		
Content	To obtain total elapse time, idle time for n jobs on 2 machines and 3 machines, two jobs on m machines.	05	CO 5
Pract 9	**Decision making under Uncertainty**		

Content	Decision making under uncertainty: Laplace criterion, Maximax (Minimum) criterion, Maximin (Minimax) criterion, Hurwitz criterion, Minimax Regret criterion.	05	CO 6
Pract 10	**Decision making under Risk and Decision tree**		
Content	Decision making under risk: Expected Monetary Value criterion, Expected Opportunity Loss criterion, Expected Payoff from Perfect Information, Expected Value of Perfect Information. Decision tree analysis.	05	CO 6
Pract 11	**Game theory: Pure Strategy, Mixed Strategy - Algebraic Method**		
Content	Finding Value of Game for Pure Strategy Two-person Zero-sum game with saddle point without saddle point-Mixed Strategy, solving 2 x 2 game using algebraic method	05	CO 6
Pract 12	**Game theory: Mixed Strategy - Graphical method, Dominance Property**		
Content	Mixed Strategy, dominance property, solving 2 x n and m x 2 game by graphical method.	05	CO 6

Reference:

1. Operations Research: Kanti Swaroop and Manmohan Gupta. Ninetheenth Edition; S Chand and Sons.(2018)
2. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
3. Mathematical Models in Operations Research: J K Sharma, Tata McGraw Hill Publishing Company Ltd.(1989)
4. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.(1975)

Examination (Total Marks): 50
Experiment Marks: 40
Journal Marks: 05
Viva Marks: 05

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. Statistics

Semester III

Name of the paper: ABILITY ENHANCEMENT COURSE (AEC)

(LANGUAGE PROFICIENCY COURSE 1)

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Course: SYBSc
Semester-III ABILITY ENHANCEMENT COURSE (AEC)
Course Title: LANGUAGE PROFICIENCY COURSE 1
Course Code: GNKUSMATAEC103
Credits: 02
No of lectures (Hours): 30
Marks: 50 (20:30)

Course Objectives:

Sr. No.	Course objectives
The course aims:	
1	To enhance language proficiency by providing adequate exposure to reading and writing skills.
2	To orient the learners towards the functional aspects of language.
3	To improve vocabulary and orthography (correct spelling).
4	To introduce learners to the genre of Science Fiction.

Course Outcomes (COs):

Sr. No.	Course Outcomes (COs):
On completing the course, the student will be able to:	
1	Developing adequate knowledge of the rules of grammar, grammatical analysis and sentence transformation.
2	Interacting effectively with academic content: Listening, Reading, Speaking, and Writing.
3	Writing effectively in various domains.
4	Utilization of information and literacy skills in Science.
5	Enhancing Reading Skills and Vocabulary.

Unit		Title	No. of lectures
Unit 1		**Advanced Language Skills: Grammar**	**15**
	1.1	Errors in usage	05
	1.2	Errors in Tenses	05
	1.3	Orthography (Spelling)	05
Unit 2		**Reading Skill: Stories from Science Fiction**	**15**
	2.1	E. M. Forster, 'The Machine Stops'	03
	2.2	Shirley Jackson, 'The Lottery'	03
	2.3	Isaac Asimov, 'Nightfall'	03
	2.4	Ray Bradbury, 'A Sound of Thunder'	03
	2.5	Ursula K. Le Guin, 'The Ones Who Walk Away from Omelas'	03

Recommended Reading:

1) Advanced Grammar in Use with Answers: A Self-Study Reference and Practice Book for Advanced Learners of English
2) Spell-IT Spelling And Vocabulary Book-1 to 5
3) 20,000 Leagues Under the Sea by Jules Verne
4) The Algebraist by Iain M. Banks
5) The Andromeda Strain by Michael Crichton
6) British science fiction: a chronology, 1478-1900 by Nicholas Ruddick
7) Brave new words: the Oxford dictionary of science fiction
8) Cambridge Companion to American Science Fiction
9) Encyclopaedia of science fiction

Examination:

- **Internal Examination (20 Marks):** Continuous Internal assessment (CIA) at department level of 20 Marks each. Average marks of any three of the following to be taken. (Quiz/PPT/Viva/Groupdiscussion/Roleplay/Casestudies/MCQ/Assignment/Journals/Record books/log book/ scrap book.)
- **End Semester theory examination (30 Marks):** Weightage of each unit will be proportional to the number of lecture hours as mentioned in the syllabus. Duration of exam: 1hour.

Combined passing of 40% with minimum 20% in Internal Component

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester IV

Major-I

Name of the paper: Probability and Sampling Distributions

(As per NEP guidelines-DSC model)

With effect from Academic Year 2024 - 2025)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: S.Y B.Sc. STATISTICS
Semester – IV: Major Paper-1
Course Title: Probability and Sampling Distributions
Course Code: GNKUSSTAMJ1104
Credits: 3
No of lectures (Hours): 45
Marks: 75 (60:40)

Course Objectives:

Sr. No.	Course objectives
The course aims at:	
1	To learn about continuous uniform, triangular distribution and their properties.
2	To learn about the Exponential, Gamma, Beta and Normal distributions along with their properties.
3	Recognize cases where the above said model could be appropriate.
4	To learn calculation of moments of above said continuous distributions.
5	To learn exact sampling distribution.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Understand the concept of first four moments, generating functions of continuous probability distributions	1	1	U & Ap
CO 2	Discuss characteristics functions of continuous probability distributions	1, 2	2	U & Ap
CO 3	Know the concept of Chi square distribution and is application	2	1, 3	U , Ap & E
CO 4	Have Knowledge of t and F distributions and their applications.	2	1, 3	U , Ap & E

SY BSc SEM IV Syllabus

Major-Paper I (Probability and Sampling Distributions)

Unit 1	**Standard Continuous Probability Distributions-I**	15	CO Mapping
1.1	**Rectangular or Continuous Uniform distribution over (a, b)** Mean, Median Standard deviation, C.D.F., M.G.F., Mean, variance, μ3 using M.G.F., skewness of distribution. For X following U (0,1), distribution of i) X/(1+X) , ii) X/(1-X) **Triangular distribution:** Symmetric and asymmetric over (a, b) with peak at c, M.G.F. Mean, Variance, c.d.f. Median.	05	CO 1
1.2	**Exponential Distribution:** Definition, M.G.F., C.G.F. raw moments and central moments up to order four using M.G.F. and C.G.F. Measures of Skewness and Kurtosis, Nature of Probability curve, Median and Quartiles and Percentiles, Forgetfulness Property with proof and examples based on it. Distribution of $X_{(1)}$ first order statistic, Distribution of ratio of two i.i.d. Exponential random variables. Distribution of 1/λ ln(1-x) if follows Uniform (0,1). Distribution of X+Y and x/(x+y), for two independent Exponential variables X and Y with mean1. (All with proof.)	05	CO 2
1.3	**Gamma Distribution (with Scale and shape parameter)** Expression for rth raw moment, Mean, variance, Mode & Standard deviation. M.G.F., Additive property, C.G.F. raw moments and central moments up to order four using M.G.F. and C.G.F., Coefficients of skewness and Kurtosis and nature of probability curve, Distribution of sum of independent Exponential random variables.	05	CO 3
Unit 2	**Standard Continuous Probability Distributions-II**	**15**	
2.1	**Beta Distribution: Type I & Type II** Expression for rth raw moment, Mean, Mode and Standard deviation, H.M., If a r.v. X follows Beta of type 1, distribution of 1- X, If a r.v. X follows Beta of type 2 distribution of (i) 1/(1+X) (ii) X/(X+Y) with proof. For two independent Gamma variables X and Y with parameters m and n respectively, distribution of U = X/Y and V=X/(X+Y) with proof.	**05**	CO 3
2.2	**Normal Distribution:** Definition, Derivation of Mean, Median, Mode, Standard deviation, M.G.F., C.G.F., Moments & Cumulants (up to fourth	**05**	CO 3

	order). skewness & kurtosis, Nature of Normal curve, Mean absolute deviation. Properties of Normal Distribution.		
2.3	Expression for even order central moments and to show that odd order central moments are zero. Percentile, Distribution of Standard normal variable, Percentiles. Distribution of linear function of independent Normal variables. Fitting of Normal Distribution. Central Limit theorem for i.i.d. random variables. (without proof). Concept of Log-Normal distribution.	**05**	CO 3
Unit 3	**Exact Sampling Distributions**	**15**	
3.1	**<u>Chi-Square Distribution:</u>** Derivation of p.d.f., Concept of degrees of freedom. Mean, Mode &Standard, deviation. M.G.F., C.G.F., Measures of skewness and Kurtosis, Additive property, Distribution of ratio of two independent Chi-square variables, Distribution of if X and Y are two independent Chi-square variables (All with proof). Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution (with proof).	**05**	CO 4
3.2	**<u>Applications of Chi-Square:</u>** Development of decision criterion with test procedures of (i) Test of significance for specified value of variance of a Normal population (ii) Test for goodness of fit, Test Procedure for independence of attributes. (i) r × c contingency table, (ii) 2×2 contingency table, Derivation of test statistic, Yates' correction with proof Derivation of Confidence interval for the variance of a Normal population when (i) mean is known, (ii) mean is unknown. **<u>Student's t-distribution:</u>** Derivation of p.d.f., Mean, Median, Mean Deviation & Standard deviation. M.G.F., C.G.F., Measures of skewness and Kurtosis and Additive property Limiting distribution of t distribution with proof.	**05**	CO 4
3.3	**<u>Applications of t:</u>** Development of decision criterion with test procedure of Test of significance for specified value of mean of Normal population. Test procedure of test of significance for difference between means of (i) two independent Normal populations with equal variances (ii) Dependent samples (Paired t test) Derivation of Confidence intervals for (i) Mean of Normal population,	**05**	CO 4

	(ii) Difference between means of two independent Normal populations having the same variance. **Snedecor's F-distribution:** Derivation of p.d.f., Expression for r^{th} raw moment, Mean, variance, Mode & Standard deviation Distribution of Reciprocal of F variable with proof. **Applications of F:** Test procedure for testing equality of variances of two independent Normal populations (i) mean is known, (ii) mean is unknown. Derivation of confidence interval for ratio of variances of two independent Normal populations.		

References:

1. Introduction to the theory of statistics: A M Mood, F.A. Graybill, D C Boyes; Third Edition; McGraw-Hill Book Company.(1973)
2. Introduction to Mathematical Statistics: R. V. Hogg, A. T. Craig; Sixth Edition; Collier McMillan Publishers.(2005)
3. Probability and Statistical Inference: R. V. Hogg, E. A. Tannis, Third Edition; Collier McMillan Publishers.(2001)
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Eighth Edition; Pearson Education Inc.(2014)
5. Introduction to Mathematical Statistics: P. G. Hoel; Fourth Edition; John Wiley & Sons Inc.

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- Combined passing of 40% with minimum 20% in Internal Component.

Course: SY B.Sc. Practical
Semester-IV: Major Paper-1
Course Title: Practical Major Paper-I (Probability and Sampling Distribution)
Course Code: GNKUSSTAMJ1P104
Credits: 01
No of Practical (Hours): 30
Marks: 25 (60:40)

Sr. No.	Course objectives
The course aims at:	
1	To know how to calculate M.G.F, C.G.F and characteristics function for continuous probability distributions
2	To learn about the Exponential, Gamma, Beta and Normal distributions along with their properties.
3	Recognize cases where the above said model could be appropriate.
4	To learn calculation of moments of above said continuous distributions.
5	To learn exact sampling distribution.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Demonstrate the skill of finding first four moments, generating functions of continuous probability distributions	1	1	U & Ap
CO 2	Demonstrate the skill of finding characteristics functions of continuous probability distributions	1, 2	2	U & Ap
CO 3	Apply the Chi-square distributions in real-life situations	2	1, 3	U , Ap & E
CO 4	Apply the basic idea of Student's t distribution and Fisher's F-distributions and their properties.	2	1, 3	U , Ap & E

Sr No	**List of Practical**
	Probability & Sampling Distribution
1	Continuous Uniform distribution
2	Triangular distribution
3	Exponential distribution
4	Gamma distribution
5	Beta Type – I
6	Beta Type -II
7	Normal Distribution.
8	Central Limit Theorem.
9	Chi Square distribution
10	Chi Square goodness of fit and testing of independences of attributes.
11	t distribution.
12	F distribution.

References:

1. Introduction to the theory of statistics: A M Mood, F.A. Graybill, D C Boyes; Third Edition; McGraw-Hill Book Company.(1973)
2. Introduction to Mathematical Statistics: R. V. Hogg, A.T. Craig; Sixth Edition; Collier McMillan Publishers.(2005)
3. Probability and Statistical Inference: R. V. Hogg, E. A. Tannis, Third Edition; Collier McMillan Publishers.(2001)
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Eighth Edition; Pearson Education Inc.(2014)

Examination:

External Practical Examination: 25 Marks
Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester IV

Major-II

Name of the paper: ANOVA and Design of Experiments

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Course: SY B.Sc. STATISTICS
Semester-IV: Major Paper-II
Course Title: ANOVA and Design of Experiments
Course Code: GNKUSSTAMJ2104
Credits: 3
No of lectures (Hours): 45
Marks: 75(60:40)

Sr. No.	Course objectives
The main of this course is to equip learners with the skills to efficiently design experiments and analyse data from those experiments to draw meaningful conclusions. In this learning learners will understand the causes of variation in the data and how it helps in analysis. **The course aims at:**	
1	To determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups.
2	To estimate treatment means, and the difference of treatment means.
3	To identify situations where one-way ANOVA is appropriate and two-way ANOVA used.
4	How to plan an experiment to make analytical comparison by means of CRD, RBD, LSD and Factorial experiments.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Know the definition and basics of the ANOVA and its uses and they will be able to define and describe two types of analytical comparisons.	1	1, 3	U & Ap
C O2	Estimate treatments mean and variance sum of square for one- way and two-way ANOVA table	1, 2	1, 2	U, E & Ap
CO 3	Understand concept of CRD, RBD and LSD design of experiments and how to choose an appropriate experimental design based on the study objectives	1, 2	1, 2	U & Ap
CO 4	Estimate treatment means and variance under various design of experiments and they will have ability to compare two designs of experiments by means of efficiency.	1, 2, 3	2, 4	U, E & Ap
CO 5	Know the concept and application of factorial design of experiments and how to analyse data under this design.	1, 3	3, 4	U, E & Ap

SY BSc SEM IV Syllabus

Major-Paper II (ANOVA and Design of Experiments)

Unit1	**Analysis of Variance**	**15**	CO Mapping
1.1	Introduction, Uses, Cochran's Theorem. **<u>One-Way ANOVA:</u>** One way classification with equal & unequal observations per class Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table.	**05**	CO 1
1.2	**<u>Two- Way ANOVA:</u>** Two-way classification with one observation per cell and 'k' observations per cell. Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table.	**05**	CO1 &CO2
1.3	Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard Error and Confidence limits for elementary treatment contrasts.	05	CO 2
Unit2	**Design of Experiments**	**15**	
2.1	Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. Efficiency of design D1 with respect to design D2.	**05**	CO3
2.2	Choice of size, shape of plots & blocks in agricultural & non-agricultural experiments. **<u>Completely Randomized Design (CRD) & Randomized Block Design (RBD):</u>** Mathematical Model, Assumptions, Expectation of various sums of squares, F-test and Analysis of variance table.	**05**	CO 4
2.3	Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of RBD relative to a CRD.	**05**	CO2
Unit3	**Latin square design and Factorial Experiments**	**15**	
3.1	**<u>Latin square design:</u>** Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators,	**05**	CO 2 & CO 3
3.2	Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of the design relative to RBD, CRD. Missing plot technique for one missing observation in case of CRD, RBD & LSD.	**05**	CO 4
3.3	**<u>Factorial Experiments:</u>**	**05**	CO 5

	Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Definition of contrast and orthogonal contrast, Yates' method. Analysis of 2^2& 2^3 factorial Experiments.		

References:

1. Experimental Designs: W.G. Cochran and G.M. Cox; Second Edition; John Wiley and Sons (1957).
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons, Second Edition (2007)
3. Design and Analysis of Experiments: Douglas C Montgomery; 6thEdition; John Wiley & Sons (2008).
4. Design and Analysis of Experiments: M.N. Das and N.C. Giri, 2nd Edition; New Age International (P) Limited;(1986).
5. Fundamentals of Applied Statistics: S.C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001).

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- **Combined passing of 40% with minimum 20% in Internal Component.**

Course: SY B.Sc. Practical
Semester-IV: Major Paper-II
Course Title: Practical Major Paper-II (ANOVA and Design of Experiments)
Course Code: GNKUSSTAMJ2P104
Credits: 01
No of Practical (Hours): 30
Marks: 25 (60:40)

Sr. No.	Course objectives
The course aims at:	
1	To determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups.
2	To estimate treatment means, and the difference of treatment means.
3	To identify situations where one-way ANOVA is appropriate and two-way ANOVA used..
4	How to plan an experiment to make analytical comparison by means of CRD, RBD ,LSD and Factorial experiments.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	To analysis one way and two ways classified data	2	3	An & Ap
CO 2	Demonstrate least significant difference is computed in ANOVA	1, 2	2, 3	An & Ap
CO 3	Illustrate the analysis of data under CRD, RBD and LSD layout	1, 2	3, 4	U, An & Ap
CO 4	To estimate missing data in various design of experiments.	1, 2, 3	2, 3, 4	U, An & Ap
CO 5	Identify the need of factorial experimentation with main and interaction effects	1, 3	3, 4	U, An & Ap

List of Practical	
ANOVA and Design of Experiment	
1	Analysis of Variance- One Way with equal observation per cell
2	Analysis of Variance- One Way with unequal observation per cell
3	Analysis of Variance- Two Way.
4	Critical Difference
5	Completely Randomized Design.
6	Randomized Block Design.
7	Latin Square Design.
8	Missing Observations in CRD, RBD & LSD.
9	Gain in efficiency of RBD over CRD
10	Gain in efficiency of LSD over RBD and CRD
11	2^2 Factorial Experiments.
12	2^3 Factorial Experiments.

References:

1. Experimental Designs: W.G. Cochran and G.M. Cox; Second Edition; John Wiley and Sons (1957).
2. The Design and Analysis of Experiments: Oscar Kempthorne, John Wiley and Sons, Second Edition (2007)
3. Design and Analysis of Experiments: Douglas C Montgomery; 6thEdition; John Wiley & Sons (2008).
4. Design and Analysis of Experiments: M.N. Das and N.C. Giri, 2nd Edition; New Age International (P) Limited;(1986).
5. Fundamentals of Applied Statistics: S.C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001).

Examination:

External Practical Examination: 25 Marks
Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science / Arts

Syllabus

Course: SY B.Sc. Mathematics / SY B.A. Economics

Semester IV

Minor

Name of the paper: Optimization Techniques

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: SY B.Sc. Mathematics / SY B.A. Economics
Semester-IV: Minor Paper
Course Title: Optimization Techniques
Course Code: GNKUSSTAMI104 / GNKUASTAMI104
Credits: 3
No of lectures (Hours): 45
Marks: 75 (60:40))

Course Objectives:

Sr. No.	Course objectives
The aim of this course is to facilitate in understanding of the concept of Operations Research. To help the students to understand the various techniques of solving problems **The course aims at:**	
1.	To obtain various models in Linear Programming Problem. To solve two variables linear programming model by the graphical method.
2.	To understand how alternative optimal solutions, infeasibility and unboundedness can occur in linear programming problems
3.	Be able to identify the special features of the transportation and assignment problems.
4.	Locate a basic feasible solution and optimal solution of a transportation problem by various methods.
5.	To understand the basics in the field of assignment problems and sequencing.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Comprehend the techniques and applications of optimization.	1, 2	1	R, Ap
CO 2	Analyse characteristics of a general linear programming problem	2	2, 3	R, Ap
CO 3	Interpret the transportation models' solutions and infer solutions to the real-world problems.	3	1, 3	R, An
CO 4	Recognize and solve assignment problems.	1, 2	2, 3	Ap, E, C
CO 5	Evaluate Total Elapsed time for processing of jobs.	2	2, 3	R & E

SY BSc / SY BA SEM IV Minor Syllabus
Minor (Optimization Techniques)

Unit 1	**Introduction to Operations Research and Linear Programming**:	15	CO Mapping
1.1	**Introduction to Operations Research:** Meaning, Definition, Origin. Need, Scope, Steps, Techniques, Application, Limitations. **Formulating of Linear Programming Problem:** Requirements, Assumptions, Applications, Advantages and Limitations. Mathematical formulation of LPP Model.	05	CO1
1.2	**Solution for two variables:** Obtaining Optimal Solution for Linear Programming Problem (LPP) and types of solutions using Graphical Method. **Solution for more than two variables:** Simplex method of solving problems with two or more variables. Big M method.	07	CO 1, CO 2
1.3	**Concept of Duality:** Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.	03	CO 2
Unit 2	**Transportation Problem**	**15**	
2.1	Introduction to the problem, LP formulation of a transportation problem. Initial Basic feasible solution by north-west corner method, least cost method, and Vogel's approximation method.	05	CO 2, CO 3
2.2	Finding optimal solution by Modified Distribution (MODI) method or uv method (u, v and Δ) after IBFS.	05	CO 3
2.3	Special cases: Degeneracy, Unbalanced transportation problem and Maximization in transportation model.	05	CO 3
Unit 3	**Assignment Problem and Sequencing**	**15**	
3.1	Meaning of assignment problem, Assignment problems features, Transportation problem Vs Assignment problem. Concept mathematical solution by: Complete enumeration method and Hungarian method for optimal solution.	05	CO 4
3.2	Variants in Assignment problem: Unbalanced, Maximization type, Travelling salesman Problem.	05	CO 4
3.3	Sequencing: Processing ‘n’ Jobs through 2 and 3 Machines & 2 Jobs through ‘m’ Machines.	05	CO 5

References:

1. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons
2. J.K.Sharma(2012) : Operations Research: Theory and applications,5thedition,Macin
3. S.D.Sharma : Operations Research; Theory, Methods and applications,15th Edition ,Reprint, Kedarnath
4. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.

Examination:

- Total: 75 Marks (60:40)
- External: 45 Marks
- Internal: 30 Marks
- **Combined passing of 40% with minimum 20% in Internal Component.**

Course: SY B.Sc / SY B. A Practical Minor
Semester-IV: Minor Paper
Course Title: Practical on Optimization Techniques
Course Code: GNKUSSTAMIP104 / GNKUASTAMIP104
Credits: 01
No of Practical (Hours): 30
Marks: 25(60:40)

Course Objectives:

Sr. No.	Course objectives
The main aim of this course is to develop the ability to find the best possible solution to a problem from a set of feasible alternatives. This involves maximizing or minimizing an objective function under certain constraints and uncertainties. studying the process of making economic and managerial decisions; analysing situations requiring decisions; studying simple and complex decision-making methods. **The course aims at:**	
1	To use quantitative methods and techniques for effective decisions–making
2	To help the students to understand the various techniques of solving problems
3	To know and use the various decision-making tools used in business.
4	To understand the basics of one to one assignment problems and job sequencing.

Course Outcomes (COs):

Sr. No.	On completing the course, the student will be able to:	POs addressed	PSOs addressed	Cognitive Levels addressed
CO 1	Comprehend the techniques and applications of optimization.	1, 2	1	R, Ap
CO 2	Analyse characteristics of a general linear programming problem	2	2, 3	R, Ap
CO 3	Interpret the transportation models' solutions and infer solutions to the real-world problems.	3	1, 3	R, An
CO 4	Recognize and solve assignment problems.	1, 2	2, 3	Ap, E, C
CO 5	Evaluate Total Elapsed time for processing of jobs.	2	2, 3	R & E

List of Practical's:

Sr No	List of practical
1	Mathematical Formulation of Linear Programming Problem.
2	Solving Linear programming problem for two variables by Graphical Method.
3	Solving Linear programming problem for three variables: Simplex method.
4	Solving Linear programming problem for three variables: Big M method.
5	Duality: The Primal Vs- Dual Solutions.
6	Transportation Problem: to obtain Initial Basic Feasible Solution.
7	Transportation Problem: to obtain optimal solution using MODI method.
8	Special cases of Transportation Problem.

9	Assignment Problem using Hungarian method.
10	Assignment Special Case: Maximization type and Travelling salesman Problem.
11	Sequencing Problem: n jobs on 2 machines and 3 machines.
12	Sequencing Problem: two jobs on m machines.

References:

1. Operations Research: Kanti Swaroop and Manmohan Gupta. Ninetheenth Edition; S Chand and Sons.(2018)
2. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
3. Mathematical Models in Operations Research: J K Sharma, Tata McGraw Hill Publishing Company Ltd.(1989)
4. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.(1975)

Examination:

External Practical Examination: 25 Marks
Journal + Viva + Exam **= 5**M + 5 M +15M

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. STATISTICS

Semester IV

Skill Enhancement Course (SEC)

Name of the paper: Statistical Analysis Using R

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)
Department of Mathematics and Statistics

Course: SY B.Sc. STATISTICS
Semester-IV: Skill Enhancement Course (SEC)
Course Title: Statistical Data Analysis using R.
Course Code: GNKUSSTASEC104
Credits: 2 (Practical Based)
No of lectures (Hours): 60
Marks: 50

Course Objectives:

Sr. No.	Course objectives
The course aims at:	
1	How to use different functions in R, how to read data into R, accessing R packages, writing R functions, debugging, and organizing data using R functions.
2	Gives an idea to collect, compile and visualize data using statistical functions
3	To analysis data for the purpose of exploration using Descriptive and Inferential Statistics.
4	To understand Probability and Sampling Distributions
5	Creative application of Linear Regression in multivariate context for predictive purpose.

Course Outcomes (COs)				
Sr. No.	**On completing the course, the student will be able to:**	**POs addressed**	**PSOs addressed**	**Cognitive Levels addressed**
CO 1	Access online resources for R and import new function packages into the R workspace	1	1	U & C
CO 2	Import, review, manipulate and summarize datasets in R	1	1	C
CO 3	Create and edit visualizations with R	2	1, 2	C, E, An
CO 4	Explore datasets to create testable hypotheses and identify appropriate statistical tests	1, 2, 3	1, 4	R, Ap & An
CO 5	Fitting various standard probability distribution	2, 3	4	E & Ap
CO 6	Correlation and Regression to analyse the underlying relationships between different variables.	1, 3	1, 2	E, C, Ap

SEC (Statistical Analysis Using R)

Pract 1	**Fundamental of R**	**No. Of hours**	**CO Mapping**
Content	Introduction to R programming: What is R?, Installing R and R Studio, R Studio Overview, Working in the Console, Arithmetic Operators, Logical Operations Using Functions. Getting Help in R and Quitting R Studio, Installing and loading packages.	05	CO 1
Pract 2	**Implement different data structures in R (Vectors, Lists, Data Frames).**		
Content	Data structures, variables, and data types in R: Creating Variables- Numeric, Character and Logical, Data – Vectors, Data Frames, Factors. Sorting Numeric, Character, and Factor Vectors - Special Values.	05	CO 2
Pract 3	**Visualization of data with different charts.**		
Content	Data Visualization using ggplot2 library: Scatter Plots, Box Plots, Scatter Plots and Box-and-Whisker Plots Together, Customize plot axes, labels, add legends, and add colours.	05	CO 2
Pract 4	**Summarizing various measure of descriptive statistics.**		
Content	Descriptive statistics in R: Measures of central tendency, Measures of variability, Skewness and kurtosis, Summary functions, describe functions, and descriptive statistics by group.	05	CO 2
Pract 5	**Testing of hypothesis for large sample test using ggstatsplot library.**		
Content	a) Testing for population means. b) Testing for difference between two population means. c) Testing for population proportion. d) Testing for difference between two population proportions.	05	CO 3
Pract 6	**Analysis of variance and chi square test using ggstatsplot library.**		
Content	**Analysis of variance:** a) One-way ANOVA b) Two-way ANOVA **Chi square test:** test for goodness of fit.	05	CO 3
Pract 7	**Evaluating probabilities of standard distribution and plotting of graph of pmf and cdf.**		
Content	For standard distributions: a) Binomial distribution b) Poisson distribution c) Hypergeometric distribution d) Uniform distribution	05	CO 4

	e) Exponential distribution f) Normal distribution		
Pract 8	**Generation of random sample and fitting of standard distributions.**		
Content	For standard distributions: a) Binomial distribution b) Poisson distribution c) Hypergeometric distribution d) Uniform distribution e) Exponential distribution f) Normal distribution	05	CO 5
Pract 9	**Correlation and simple regression.**		
Content	Computing Pearson Correlation and Spearman Rank Correlation. Building simple regression model and interpretating significance of the model.	05	CO 6
Pract 10	**Fitting various mathematical curves.**		
Content	Analysis simple time series data and fitting various mathematical curves. (i) Quadratic (ii) Power curve (iii) Exponential curve	05	CO 6
Pract 11	**Case study on summarizing the descriptive statistics.**	05	CO 2
Pract 12	**Case study on reviewing inferential statistics.**	05	CO 2

References:

1. R Cookbook, PaulTeetor, Oreilly: R Cookbook [R CKBK] [Paperback] R Cookbook [RKBK] [Paperback]Mar 31, 2011 by Paul Teetor.
2. R in Action, Rob Kabacoff, Manning: R in Action: Data Analysis and Graphics with R, Nov 5, 2018 | Unabridged by Robert Kabacoff and Dale Ogden.
3. Michael Akritas, " Probability & Statistics with R for Engineers and Scientists", 2nd Edition on, CRC Press, 2016.

Examination (Total Marks): 50
Experiment Marks: 40
Journal Marks: 05
Viva Marks: 05

Shiromani Gurudwara Prabandhak Committee's

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Matunga, Mumbai – 400 019, Maharashtra

Program: Bachelor of Science

Syllabus

Course: SY B.Sc. Statistics

Semester IV

Name of the paper: ABILITY ENHANCEMENT COURSE (AEC)

(LANGUAGE PROFICIENCY COURSE 2)

(As per NEP guidelines-DSC model)

With effect from Academic Year 2026 - 2027)

Guru Nanak Khalsa College of Arts, Science and Commerce (Autonomous)

Course: SYBSc
Semester-IV ABILITY ENHANCEMENT COURSE (AEC)
Course Title: LANGUAGE PROFICIENCY COURSE 2
Course Code: GNKUSSTAAEC104
Credits: 02
No of lectures (Hours): 30
Marks: 50 (20:30)

Course Objectives:

Sr. No.	Course objectives
The course aims:	
1	To enhance language proficiency by providing adequate exposure to reading and writing skills.
2	To orient the learners towards the functional aspects of language.
3	To improve vocabulary and orthography (correct spelling).
4	To introduce learners to the genre of Science Fiction.

Course Outcomes (COs):

Sr. No.	Course Outcomes (COs):
On completing the course, the student will be able to:	
1	Developing adequate knowledge of the rules of grammar, grammatical analysis and sentence transformation.
2	Interacting effectively with academic content: Listening, Reading, Speaking, and Writing.
3	Writing effectively in various domains.
4	Utilization of information and literacy skills in Science.
5	Enhancing Reading Skills and Vocabulary.

Unit		Title	No. of lectures
Unit 1		**Studying Science Fiction**	**15**
	1.1	Jules Verne: Journey to the Centre of the Earth	15
Unit 2		**Writing Skills**	**15**
	2.1	Editing Skills	05
	2.2	Scientific Writing	05
	2.3	Writing a Research Article	05

Recommended Reading:

1) Advanced Grammar in Use with Answers: A Self-Study Reference and Practice Book for Advanced Learners of English
2) Spell-IT Spelling And Vocabulary Book-1 to 5
3) 20,000 Leagues Under the Sea by Jules Verne
4) The Algebraist by Iain M. Banks
5) The Andromeda Strain by Michael Crichton
6) British science fiction: a chronology, 1478-1900 by Nicholas Ruddick
7) Brave new words: the Oxford dictionary of science fiction
8) Cambridge Companion to American Science Fiction
9) Encyclopaedia of science fiction

Examination:

- **Internal Examination (20 Marks):** Continuous Internal assessment (CIA) at department level of 20 Marks each. Average marks of any three of the following to be taken. (Quiz/PPT/Viva/Groupdiscussion/Roleplay/Casestudies/MCQ/Assignment/Journals/Record books/log book/ scrap book.)
- **End Semester theory examination (30 Marks):** Weightage of each unit will be proportional to the number of lecture hours as mentioned in the syllabus. Duration of exam: 1hour.

Combined passing of 40% with minimum 20% in Internal Component.

Course Outcomes

Bloom's Taxonomy categorizes educational objectives into six cognitive levels, listed from the simplest to the most complex.

The course outcomes (CO) are mapped to the revised Bloom's Taxonomy using the following Cognitive levels along with abbreviations: **Remembering-R, Understanding-U, Applying-Ap, Analyzing-An, Evaluating-E, Creating-C.**

R-Remembering: This level involves recalling facts, terms, basic concepts, and answers without necessarily understanding the meaning or implications.

U-Understanding: Understanding involves explaining ideas or concepts and interpreting them in one's own words to demonstrate comprehension.

Ap-Applying: Applying knowledge involves using acquired knowledge in new situations or applying it in different ways.

An-Analyzing: Analyzing involves breaking down information into parts to understand its organizational structure, recognizing patterns, and identifying relationships between components.

E-Evaluating: Evaluating involves making judgments based on criteria and standards, assessing the value of theories, presentations, or materials.

C-Creating: Creating involves putting elements together to form a coherent or functional whole, reorganizing elements into a new pattern or structure.

Use the following action verbs for Blooms taxonomy levels to prepare Course outcomes:

No	Levels	Action verbs
1	**Remember**	Choose, Describe, Define, Label List, Locate,, Match, Memorize, Name, Omit, Recite, Select, State, Count, Draw, Outline, Point, Quote, Recall, Recognize, Repeat, Reproduce, Recall, Arrange, Duplicate, Tabulate.
2	**Understand**	Restate ,Discuss, Clarify, Locate, Recognise, Classify, Translate, Explain, Express, Review, Interpret, Select, Summarise, Contrast, Predict, Associate, Estimate, Extend
3	**Apply**	Demonstrate, Schedule, Operate, Dramatize, Apply, Employ, Use, Practise, Illustrate, Choose, Solve, Write, Calculate, Complete, Show, Examine, Modify, Relate, Classify, Experiment.
4	**Analyse**	Distinguish, Differentiate, Investigate, Categorise, Appraise, Inspect, Test, Debate, Compare, Contrast, Question
5	**Evaluate**	Judge, Score, Select, Evaluate, Choose, Rate, Assess, Compare, Estimate, Value, Measure, Discriminate, Argue, Defend, Support, Conclude, Summarize, Appraise, Revise.
6	**Create**	Compose, Assemble, Organise, Plan, Collect, Propose, Construct, Design, Create, Formulate, Arrange, Devise, Modify, Derive, Develop, Integrate, Rearrange, Substitute, Invent, Generalise.