Deccan Education Society's

Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum
for 3/4 years B. Sc. /B. Sc. (Honours) Programme
as per guidelines of

NEP-2020: 2.0

for

F. Y. B. Sc. (Statistics)

With effect from Academic Year
2024-2025

Program Outcomes (POs) for B. Sc.

PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic competence:** (i) Recall summary statistics for quantitative and qualitative data, basic concepts of probability, infinite series, concepts of financial mathematics for actuarial statistics. (ii) Understand concept of correlation and regression, multiple regression, probability distributions and their characteristic properties, some standard discrete and continuous probability models, theory of inference.
PSO2	**Personal and Professional Competence:** (i) Simulate various probability distributions using various random number generation procedures. (ii) Apply the statistical techniques that involve exploratory and confirmatory data analysis to the real life data collected through sample surveys, and prepare project reports.
PSO3	**Research Competence:** Plan statistical designing of experiments ,learn its applications and analysis, learn modelling and analysis of time series data ,forecasting of time series, create life tables and decide life insurance policy premiums , learn modelling of different probability distributions , use of R-software for statistical analysis.
PSO4	**Entrepreneurial and Social competence:** Employ the process of thinking independently, taking initiative, working in a team effectively, preparing project reports and developing capability to lead the team through real life projects.

NEP 2.0 Subject Credit Distribution Structure 2024-25

Department of Statistics
Course Structure

FYBSc Sem -I	Theory/ Practical	Paper Code	Paper Title	Credits	Exam type
Discipline Specific Core, DSC	Theory	STS-1001	Descriptive Statistics	2	CE +ESE
Discipline Specific Core, DSC	Practical	STS-1011	Statistics Practical-1	2	CE +ESE
SEC for Computer Science	Practical	STS-1091	Statistics Techniques-I	2	CE +ESE
Minor for BA	Theory	STS-1111	Introduction to Descriptive Statistics-I	4	CE +ESE

FYBSc Sem -II	Theory/ Practical	Paper Code	Paper Title	Credits	Exam type
Discipline Specific Core, DSC-3	Theory	STS-1002	Probability Theory and Distributions	2	CE +ESE
Discipline Specific Core, DSC-4	Practical	STS-1012	Statistics Practical-2	2	CE +ESE
Skill Enhancement Course, SEC-1	Theory/ Practical	STS-1032	Basics of Statistics Using R-I	2	Only CE
SEC for Computer Science	Practical	STS-1092	Statistics Techniques-II	2	CE +ESE
Minor for BA	Theory	STS-1112	Introduction to Descriptive Statistics-II	4	CE +ESE

* *SEC- Skill Enhancement Component.*

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	3 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

F. Y. B. Sc. Semester-I		
STS-1001	**Descriptive Statistics** **(Major-Theory)**	**Credits: 02** **Hours : 30**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's cognitive level**
CO1	Recall the concepts of statistical population and sample	1
CO2	Articulate the data and its type and summarize information in the data using different summary measures. Explain simple regression models, fitting of second degree and exponential curves, computation of price, quantity indices and study of qualitative data.	2
CO3	Apply methods and procedures of summarizing information in real life situations in various fields. Apply appropriate statistical models to data generated in day to day life, Calculate various price and quantity indices and Yule's coefficient of association.	3
CO4	Analyze the bivariate quantitative data. Identify the situations for simple linear and multiple linear regression models.	4
CO5	Judge and make comparisons through the exploratory data analysis and summary measures. Compare fitted models on the basis of residual analysis and coefficient of determination.	5
CO6	Organize and summarize the information by suitable presentations and computations. Formulate the real-life situations in terms of regression analysis.	6

Unit No.	Title of Unit and Contents	No. of Lectures
I	**Population and Sample:** 1.1 Types of characteristics: Attributes: Nominal scale, ordinal scale, Likert scale, Variables: Interval scale, ratio scale discrete and continuous variables. 1.2 Types of data: Primary data, Secondary data, Cross-sectional data, Time series data, Directional data. 1.3 Notion of a statistical population and sample: Finite population, infinite population, homogeneous population and heterogeneous population. Sample and a random sample. 1.4 Methods of sampling (description only): Simple random sampling with and without replacement (SRSWR and SRSWOR), Stratified Random Sampling, Systematic Sampling, Cluster sampling and Two-stage sampling. Inclusion probabilities.	(04)

II	**Summary Statistics:**	(10)
	2.1 Classification: Raw data and its classification, ungrouped frequency distribution, grouped frequency distribution, cumulative frequency distribution, inclusive and exclusive methods of classification, open end classes, relative frequency distribution.	
	2.2 Measures of Central Tendency: Concept of central tendency of statistical data, Statistical averages, characteristics of a good statistical average. Arithmetic Mean (A.M.): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, Trimmed arithmetic mean. Mode and Median: Definition, merits and demerits. Empirical relation between mean, median and mode. Partition values: Quartiles, Deciles and Percentiles. Geometric Mean (G.M.): Definition, merits and demerits. Harmonic Mean (H.M.): Definition, merits and demerits. Order relation between arithmetic mean, geometric mean, harmonic mean. Weighted Mean: weighted A.M., G.M. and H.M. Situations where one kind of average is preferable to others.	
	2.3 Measures of Dispersion: Concept of dispersion, characteristics of good measure of dispersion. Range, Semi-interquartile range (Quartile deviation): Definition, merits and demerits. Mean deviation: Definition, merits and demerits, minimality property (without proof) Mean squared deviation: Definition, minimality property of mean squared deviation Variance and standard deviation: Definition, merits and demerits, effect of change of origin and scale, combined variance for n groups (derivation for two groups). Measures of dispersion for comparison: Coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.).	
III	**Moments, Skewness and Kurtosis:**	(06)
	3.1 Moments: Raw moments (m'_r) for ungrouped and grouped data. Central moments (m_r) for ungrouped and grouped data, Effect of change of origin and scale. Relations between central moments and raw moments upto 4th order (with proof).	
	3.2 Concept of skewness of frequency distribution, positive skewness, negative skewness, symmetric frequency distribution and its relation with central tendency. Bowley's coefficient of skewness: Bowley's coefficient of skewness lies between -1 to 1, interpretation using box and whisker plot. Karl Pearson's coefficient of skewness. Measures of Skewness based on moments (β_1, γ_1).	
	3.3 Concepts of kurtosis, Types of kurtosis: Leptokurtic, Mesokrtic and Platykurtic frequency distributions and its relation with dispersion. Measures of kurtosis based on moments (β_2, γ_2). Properties of β_1 and β_2 (i) $\beta_2 \geq 1$ (ii) $\beta_2 \geq \beta_1 + 1$	

IV	**Correlation, Regression and Curve fitting:**	(10)
	4.1 Bivariate data, Scatter diagram and interpretation.	
	4.2 Concept of correlation between two variables, positive correlation, negative correlation, no correlation. Covariance between two variables (m11) : Definition, computation, effect of change of origin and scale. Karl Pearson's coefficient of correlation I : Definition, Properties:	
	(i) $-1 \leq r \leq 1$ (with proof),	
	(ii) Effect of change of origin and scale (with proof). computation for ungrouped data and grouped frequency distributed data with interpretation.	
	4.3 Spearman's rank correlation coefficient: Definition, derivation of formula, computation and interpretation (without ties). In case of ties, compute Karl Pearson's correlation coefficient between ranks. (Spearman's rank correlation coefficient formula with correction for ties not expected.)	
	4.4 Meaning of regression, difference between correlation and regression. Concept of error in regression, error modeled as a continuous random variable. Simple linear regression model: $Y = a + b X + \varepsilon$, where ε is a continuous random variable with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$. Estimation of a, b by the method of least squares. Interpretation of parameters. Statement of the estimator of σ^2. Concept of residual, plot of residual against X, concept of coefficient of determination.	
	4.5 Fitting of second degree curve $(Y = a + b X + cX^2)$,	
	4.6 Fitting of exponential curves of the type $Y = a\,b^X$ and $Y = aX^b$. In all these curves, parameters are estimated by the method of least squares.	

References:

1. Agarwal, B. L. (2003). Programmed Statistics, 2nd Edition, New Age International Publishers, New Delhi.
2. Das (2009). Statistical Methods, Tata Mcgraw Hill Publishing
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. 1, 6th Revised Edition, The World Press Pvt. Ltd., Calcutta.
4. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3rd Edition, Sultan Chand and Sons Publishers, New Delhi.
5. Krzanowski (2007). Statistical Principals and Techniques in Scientific and Social Research, Oxford University Press Inc., New York
6. Mukhopadhyay P. (2015). Applied Statistics, Publisher: Books & Allied (P) Ltd.
7. Mohanty (2016). Basic Statistics, Scientific Publisher
8. Rastogi (2015). Biostatistics, 3rd Edition, Publisher Medtec

9. Robert S. Witte, John S. Witte (2017). Statistics, Publisher: Wiley
10. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers (1998).

    Probability and Statistics for Engineers and Scientists, Publisher, Prentice Hall.

11. Sarma, K. V. S. (2001). Statistics Made It Simple: Do it yourself on PC, Prentice Hall of India, New Delhi.

12. Lefebvre Mario (2006) Applied probability and Statistics, Publisher Springer. **Links:** https://mahades. mamarashtra.gov.in

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    http://www.isical.ac.in
    https://iipsindia.org

F. Y. B. Sc. Semester-I		
STS-1011	**Statistics Practical-1** **(Major-Practical)**	**Credits : 2** **Hours : 60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's cognitive level**
CO1	Present the data diagrammatically and graphically.	1
CO2	Articulate the data and its type and summarize information in the data using different summary measures. Explain simple regression models, fitting of second degree and exponential curves, computation of price, quantity indices and study of qualitative data.	2
CO3	Apply methods and procedures of summarizing information in real life situations in various fields. Apply appropriate statistical models to data generated in day to day life, Calculate various price and quantity indices and Yule's coefficient of association.	3
CO4	Analyze the bivariate quantitative data. Identify the situations for simple linear and multiple linear regression models.	4
CO5	Judge and make comparisons through the exploratory data analysis and summary measures. Compare fitted models on the basis of residual analysis and coefficient of determination.	5
CO6	Organize and summarize the information by suitable presentations and computations. Formulate the real-life situations in terms of regression analysis.	6

Sr. No.	Title of the Experiment
1.	Diagramatic Representation [Pie –Chart Bar diagram, Subdivided Bar diagram, Multiple Bar diagram, Percentage Bar diagram Pareto Chart]
2.	Graphical Presentation [Histogram, Frequency Polygon, Cumulative frequency curves, Stem and leaf chart]
3.	Measures of central tendency – I [Mean Median, Mode, quantiles]
4.	Measures of central tendency – II [Geometric mean, Harmonic mean, Trimmed mean, weighted mean, combined mean]
5.	Measures of dispersion – I [Measures of absolute dispersion, combined variance]
6.	Measures of dispersion – II [Measures of relative dispersion]
7.	Measures of skewness and kurtosis
8.	Random sampling and summary Statistics
9.	Correlation [With and without ties]
10.	Rank Correlation
11.	Simple linear Regression
12.	Curve Fitting
13, 14 and 15	Case study

Computer Science Semester-I		
STS-1091	**Skill Enhancement Course [SEC]** **Statistical Techniques I**	**Credits : 2**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's cognitive level**
CO1	Identify the appropriate diagram for the given data.	1
CO2	Discuss various applications of statistical measures using R software.	2
CO3	Execute the computational techniques using R software.	3
CO4	Analyze different concepts of statistics using R software.	4
CO5	Determine chance of an event based on prior knowledge of conditions related to that event.	5
CO6	Write a program using R to build different regression models for the given data and estimate the error.	6

Sr. No.	Title of Experiment/ Practical
1	Introduction to R and Graphical methods using R
2	Measure of Central Tendency and Dispersion
3	Measure of Central Tendency and Dispersion using R
4	Measures of skewness and kurtosis
5	Measures of skewness and kurtosis using R
6	Correlation and Regression, verification using R
7	Fitting of Second degree and Exponential curves, verification using R
8	Basic probability theory
9	Advanced theory of Probability
10	Discrete probability theory
11	Model sampling from discrete probability distributions using R
12	Fitting of Binomial and Poisson distribution using R
13,14&15	Applications of statistical techniques to real life data.

References:

1. Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1989.
2. Fundamentals of Applied Statistics (4th Edition), Gupta and   Kapoor, S. Chand and Sons, New Delhi, 2014.
3. Modern Elementary Statistics, Freund J.E., Pearson Publication, 2005.
4. A First course in Probability 6th Edition, Ross, Pearson Publication, 2006.
5. Statistics Using R, S.G.Purohit, S.D.Gore, S. R. Deshmukh, Narosa Publishing House, 2018

F.Y.B.A. Semester-I	
STS-1111	**Introduction to Descriptive Statistics-I** **(Minor-Theory)**	**Credits : 04** **Hours : 60**

	Course Outcomes (COs) On completion of the course, the students will be able to:	Bloom's cognitive level
CO1	Recall statistical population and sample, need of Statistics and information about National Statistical Institutes.	1
CO2	Articulate the data, its types and summarize information in the data using different measures.	2
CO3	Apply methods and procedures of summarizing information in real life situations in different fields	3
CO4	Assess preliminary judgments and comparisons through exploratory data analysis and summary measures.	4
CO5	Compare different measures of summary statistics.	5
CO6	Create different frequency distributions for real life data	6

Unit. No.	Title of Unit and Contents	No. of Lectures
I	**Introduction to Statistics:** 1.1 Meaning of Statistics as a Science. 1.2 Importance of Statistics. 1.3 Scope of Statistics: In the field of Industry, , Economics, Social Sciences, Management sciences, Agriculture, Insurance, Information technology, Education and Psychology Biological sciences, Medical sciences. 1.4 Statistical organizations in India and their functions: CSO, ISI, NSS, IIPS (Devnar, Mumbai), Bureau of Economics and Statistics.	**(04)**
II	**Population and Sample:** 2.1 Types of characteristics: Attributes: Nominal scale, Ordinal scale, Variables: Interval scale, Ratio scale, discrete and continuous variables, difference between linear scale and circular scale 2.2 Types of data: (a) Primary data, Secondary data (b) Cross-sectional data, time series data. 2.3 Notion of a statistical population: finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sample	**(06)**

		2.4 Methods of sampling (description only): Simple random sampling with and without replacement (SRSWR and SRSWOR), stratified random sampling, systematic sampling, cluster sampling and two-stage sampling	
III	**Summary Statistics:** Review / Revision of Presentation of Data 3.1 Classification: Raw data and its classification, ungrouped frequency distribution, Sturges' rule, grouped frequency distribution, cumulative frequency distribution, inclusive and exclusive methods of classification, Open end classes, and relative frequency distribution. 3.2 Measures of Central Tendency Review / Revision of following topics: Concept of central tendency of statistical data, Statistical averages, characteristics of a good statistical average. Arithmetic Mean (A.M.): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, trimmed arithmetic mean, mode and median: Definition, formulae, merits and demerits. Empirical relation between mean, median and mode . Partition Values: Quartiles, Deciles and Percentiles, Box Plot. Geometric Mean (G.M.): Definition, formula, merits and demerits. Harmonic Mean (H.M.): Definition. Formula, merits and demerits. Orderly relation between arithmetic mean, geometric mean, harmonic mean Weighted Mean: weighted A.M., G.M. and H.M. Situations where one kind of average is preferable to others. 3.3 Measures of Dispersion Review / Revision of following topics: Concept of dispersion, characteristics of good measure of dispersion. Range, Semi-interquartile range (Quartile deviation): Definition, merits and demerits, Mean deviation, Definition, merits and demerits, minimality property (without proof), Variance and standard deviation: Definition, merits and demerits, effect of change of origin and scale, combined variance for n groups (derivation for two groups). Mean squared deviation: Definition, minimality property of mean squared deviation (without proof), Measures of dispersion for comparison: coefficient of \ range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.)	**(20)**		

IV	**Moments, Skewness and Kurtosis**	(15)
	4.1 Raw moments (m'_r) for ungrouped and grouped data.	
	4.2 Central moments (m_r) for ungrouped and grouped data, Effect of change of origin and scale.	
	4.3 Relations between central moments and raw moments, upto 4th order (without proof).	
	4.4 Concept of skewness of frequency distribution, positive skewness, negative skewness, symmetric frequency distribution.	
	4.5 Bowley's coefficient of skewness : Bowley's coefficient of skewness lies between -1 to 1 (with proof), interpretation using Box plot.	
	4.6 Karl Pearson's coefficient of skewness.	
	4.7 Measures of skewness based on moments (β_1, γ_1).	
	4.8 Concepts of kurtosis, leptokurtic, mesokurtic and platykurtic frequency distributions.	
	4.9 Measures of kurtosis based on moments (β_2, γ_2).	
V	**Index Numbers**	(15)
	5.1 Introduction.	
	5.2 Definition and Meaning.	
	5.3 Problems/considerations in the construction of index numbers.	
	5.4 Simple and weighted price index numbers based on price relatives.	
	5.5 Simple and weighted price index numbers based on aggregates.	
	5.6 Laspeyre's, Paasche's and Fisher's Index numbers.	
	5.7 Consumer price index number: Considerations in its construction. Methods of construction of consumer price index number - (i) family budget method (ii) aggregate expenditure method.	
	5.8 Shifting of base, splicing, deflating, purchasing power.	
	5.9 Description of the BSE sensitivity and similar index numbers.	

References:
1. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, New Delhi.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.
3. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.
4. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, New Delhi.
5. Freund, J. E. (1977). Modern Elementary Statistics. Fourth Edition, Prentice Hall of India Private Limited, New Delhi.
6. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, New Delhi.
7. Snedecor G. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. East- West Press.

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<table>
<tr><td colspan="3" align="center">F. Y. B. Sc. Semester-II</td></tr>
<tr><td>STS-1002</td><td align="center">Probability Theory and Distributions
(Major-Theory)</td><td>Credits : 02
Hours : 30</td></tr>
<tr><td colspan="2" align="center">Course Outcomes (COs)
On completion of the course, the students will be able to:</td><td align="center">Bloom's cognitive level</td></tr>
<tr><td>CO1</td><td>Describe random and non-random experiments.</td><td align="center">1</td></tr>
<tr><td>CO2</td><td>Articulate the probabilities of events including frequentist and axiomatic approach.</td><td align="center">2</td></tr>
<tr><td>CO3</td><td>Explain concept of discrete random variable and its probability distribution including expectation and moments.</td><td align="center">3</td></tr>
<tr><td>CO4</td><td>Illustrate the concept of two dimensional discrete random variables, bivariate probability distributions.</td><td align="center">4</td></tr>
<tr><td>CO5</td><td>Identify different real life situations for the discrete distributions</td><td align="center">5</td></tr>
<tr><td>CO6</td><td>Construct univariate and bivariate probability models for real life situations.</td><td align="center">6</td></tr>
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<tr><td>Unit No.</td><td align="center">Title of Unit and Contents</td><td>No. of Lectures</td></tr>
<tr><td align="center">I</td><td>Probability, conditional probability, independence:
1.1 Experiments / Models, deterministic and non- deterministic   models. random experiment, concept of statistical regularity.
1.2 Definitions of - (i) Sample space, (ii) Discrete sample space: finite and countably infinite, (iii) Continuous sample space, (iv) Event, (v) Elementary event, (vi) Complement of an event, (vii) Certain event, (viii) Impossible event. Concept of occurrence of an event.
1.3 Algebra of events and its representation in set theory notation. Classical definition of probability and its limitations. Probability model, equiprobable and non-equiprobable sample space.
1.4 Axiomatic definition of probability, theorems of probability, computation of probability of an event conditional probability of an event.
1.5 Independence of two events. Pair-wise independence and mutual independence for three events. Multiplication theorem $P(A \cap B) = P(A) \cdot P(B|A)$ and its generalization.
1.6 Bayes' Theorem Partition of the sample space. Proof of Bayes' theorem, Applications of Bayes' theorem in real life.</td><td align="center">(08)</td></tr>
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II	**Univariate Probability Distributions:** 2.1 Concept and definition of a discrete random variable. Probability mass function (p.m.f.) and distribution function (d.f.), FX (·), of discrete random variable, properties of distribution function. Mode and median of a univariate discrete probability distribution. 2.2 Definition of expectation (mean) of a random variable, properties of expectation, expectation of a function of a random variable, moment generating function (m.g.f.) and cumulant generating function (c.g.f.) and their properties. 2.3 Definitions of variance, properties of variance, standard deviation (s.d.) and coefficient of variation (c.v.) of univariate probability distribution 2.4 Definition of raw, central moments and factorial raw moments of univariate probability distributions and their interrelations. Coefficients of skewness and kurtosis based on moments.	(8)
III	**Bivariate discrete probability distribution:** 3.1 Definition of two-dimensional discrete random variable, its joint p.m.f. and its distribution function and their properties, concept of identically distributed random variables computation of probabilities of events in bivariate probability distribution. 3.2 Concepts of marginal and conditional probability distributions. Independence of two discrete random variables based on joint and marginal p.m.f, Definition of raw and central moments. 3.3 Theorems on expectations of sum and product of two jointly distributed random variables, Conditional expectation, Definitions of conditional mean and conditional variance, Definition of covariance, coefficient of correlation, variance of linear combination of variables i.e. var(aX + bY). Illustrations of some standard bivariate probability distributions.	(06)
IV	**Discrete Probability Distributions based on finite sample space:** 4.1 Degenerate distribution (one point distribution) p.m.f.: $P(X=c) =1$, mean and variance. 4.2 Discrete Uniform distribution: p.m.f. $$P(X=x) = \begin{cases} \dfrac{1}{n} & ,x = 1,2\ldots n \\[2mm] 0 & , \text{otherwise} \end{cases}$$ mean, variance, real life situations, comments on mode and median. 4.3 Bernoulli distribution: p.m.f. $$P(X=x)= \begin{cases} p^x(1-p)^{1-x} & ,x = 0,\ 1 \\ & 0 < p < 1 \\ 0 & otherwise \end{cases}$$ mean, variance and moments.	(08)

4.4 Binomial distribution: p.m.f.

$$P(X=x) = \begin{cases} \binom{n}{x} p^x q^{n-x}, x = 0,1,\dots,n \\ \qquad 0 < p < 1, q = 1 - p \\ \\ 0 \qquad\qquad \text{otherwise} \end{cases}$$

Notation: $X \sim B(n, p)$. , situations where this distribution is applicable. mean, variance, recurrence relation for successive probabilities, computation of probabilities of different events, mode of the distribution, m.g.f., c.g.f., moments, skewness (comments when $p = 0.5$, $p > 0.5$, $p < 0.5$), additive property.

4.5 Hypergeometric Distribution: p.m.f

$$P(X = x) = \begin{cases} \dfrac{\binom{M}{x}\binom{N-M}{n-x}}{\binom{N}{n}}, x = 0,1,\dots \min\{n, M\}, N > M \\ \\ 0 \qquad \text{otherwise} \end{cases}$$

Notation : $X \sim H(N, M, n)$, situations where this distribution is applicable, mean and variance, binomial approximation to hypergeometric distribution, computation of probabilities.

References:
1. Agarwal B. L. (2003). Programmed Statistics, 2nd edition, New Age International Publishers, New Delhi.
2. B. L. S. Prakasarao, (2008). A First Course in Probability and Statistics, World Scientific Publishing Company.
3. Hoel P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
4. Hogg, R. V. and Craig R. G. (1989). Introduction to Mathematical Statistics, MacMillan Publishing Co., New York.
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6. Ross S. (2002). A First Course in Probability, 6th edition, Pearson Education, Inc. & Dorling Kindersley Publishing, Inc.
7. Roussas, George G. (2016). First course in mathematical statistics. 2nd edition Publisher: Academic Press.
8. Walpole and Myres, (1986). Mathematical Statistics, 4th edition, Publisher: Longman Higher Education.
9. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, 8th Edition, Sultan Chand and Sons Publishers, New Delhi.
10. Lefebvre Mario (2006) Applied Probability and Statistics, Publisher Springer
11. Mayer, P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co., London.
12. Mukhopadhyay P (2006) Mathematical Statistics Books Allied (P) Ltd.

F. Y. B. Sc. Semester-II		
STS-1012	**Statistics Practical-2** **(Major-Practical)**	Credits: 02 Hours : 60
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	Bloom's cognitive level
CO1	Identify real life situations of various discrete distributions.	1
CO2	Fit different discrete distributions.	2
CO3	Compute probability and conditional probability.	3
CO4	Verify dependence and independence of events.	4
CO5	Model sampling from different discrete distributions	5
CO6	Construct univariate probability distributions	6

	Title of Experiment / Practical
1.	Permutation and Combination.
2.	Computation of probability and conditional probability.
3.	Mutual and Pairwise independence of events.
4.	Applications of Bayes' theorem.
5.	Construction of univariate probability distributions.
6.	Model Sampling from binomial.
7.	Applications of Bernoulli and Binomial Distributions, Hypergeometric.
8.	Fitting of binomial distribution.
9	Bivariate probability distributions Construction of probability distribution, marginal probability distribution.
10	Bivariate probability distributions Obtaining conditional probability distribution checking independence.
11	Bivariate probability distributions Obtain expectation variance, covariance correlation coefficient.
12	Bivariate probability distributions Obtaining conditional l mean and conditional variance, variance of liner combination
13,14 and 15.	Exploring fitting of discrete distributions to real life data.

F. Y. B. Sc. Semester-II		
STS-1032	**Basics of Statistics Using R-I** **(SEC-1)**	**Credits: 02** **Hours : 30**
Course Outcomes (COs) On completion of the course, the students will be able to understand:		**Bloom's cognitive level**
CO1	Understand the R environment for downloading, installing, and using packages, debug, organize, and comment R code	1
CO2	Articulate Basic R programming with some basic notions for developing their own simple programs and visualizing graphics in R.	2
CO3	Explain how to extract and Read data into R, manipulate, and analyze it	3
CO4	Illustrate various methods of generating random sample from Population using R	4
CO5	Identify the methods and procedures of summarizing information by using summary statistics such as measures of central tendency, dispersion, skewness kurtosis using R	5
CO6	Apply correlation analysis to different realistic situations using R	6
	Note: Students are expected to write commands in script file wherever applicable.	

Unit No.	Title of Unit and Contents	No. of Lectures
I	**Fundamentals of R:** 1.1 Overview of the R language, Input and output of data in R, Help command, In-built functions in R, installing packages and libraries, Data Types in R; Vectors, Matrices, Arrays, and Data Frames, Important operations of these Data Types, 1.2 Creating a vector using scan function, creating a data frame using edit command, Importing data from MS-Excel file Using read.table command, saving the R-output in a file using MS-Excel, concept of R-script file, Graphics using R: (a) High level plotting functions (b) Low level plotting functions (c) Interactive graphic functions The following statistical methods using „R" 1.3 **Diagrams** Simple bar diagram, Subdivided bar diagram, multiple bar diagram, Pie diagram, Stem and leaf diagram 1.4 **Graphs** Boxplot for one and more than one variables, rod or spike plot, histogram for raw data with prob=T option and for both equal and unequal class intervals, frequency polygon, ogive curves, empirical distribution function Saving the diagram and graph in MS-Word file	**(10)**

II	**Summary Statistics using R:**
	    Population and Sample
	2.1 Methods of sampling: generating random sample using Simple random sampling with and without replacement (SRSWR and SRSWOR)
	2.2 Stratified Random Sampling, Systematic Sampling, Cluster sampling and Two-stage sampling.
	    Measures of Central Tendency:
	2.3 Computation of the following for ungrouped and grouped data:
	    Arithmetic Mean (A.M.)
	    Mode and Median, Partition values: Quartiles, Deciles and Percentiles. Geometric Mean (G.M.) Harmonic Mean (H.M.),
	    Measures of Dispersion
	2.4 Computation of the following for ungrouped and grouped data:
	    Range, Semi-interquartile range (Quartile deviation):
	    Mean deviation, Variance and standard deviation, Mean squared deviation, coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.).
		(11)

III	**Moments, Skewness and Kurtosis using R:** Computation of following measures for ungrouped and grouped data: 3.1 Raw moments (m'_r), Central moments (m_r) 3.2 Computation of Bowley's coefficient of skewness, interpretation using box and whisker plot. Karl Pearson's coefficient of skewness. 3.3 Measures of Skewness based on moments (β_1, γ_1). kurtosis, Types of kurtosis: Leptokurtic, Mesokrtic and Platykurtic frequency distributions and its relation with dispersion. Measures of kurtosis based on moments (β_2, γ_2).	**(05)**
IV	**Correlation using R:** 4.1 Bivariate data, Scatter diagram and interpretation. 4.2 correlation between two variables, positive correlation, negative correlation, no correlation. 4.3 Covariance between two variables (m_{11}) 4.4 Karl Pearson's coefficient of correlation 4.5 Spearman's rank correlation coefficient (without ties). In case of ties, compute Karl Pearson's correlation coefficient between ranks. (Spearman's rank correlation coefficient formula with correction for ties not expected.)	**(04)**

References:
1.   Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London 32
2.   Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall / CRC Press, New York
3.   Shahababa, B. (2011). Biostatistics with R, Springer, New York
4.   Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi. Eighth Ed. East - West Press. Statistics, Vol. 1, 6th revised edition, The World Press Pvt. Ltd., Calcutta.

F. Y. B. Sc. Semester-II		
STS-1092	**Skill Enhancement Course [SEC]** **Statistical Techniques II**	**Credits: 02** **Hours : 60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		**Bloom's** **cognitive level**
CO1	Identify appropriate tests of hypotheses to the given data.	1
CO2	Discuss and implement various applications of statistical techniques using R.	2
CO3	Demonstrate multiple regression model.	3
CO4	Compare parametric and non-parametric tests of hypothesis	4
CO5	Determine an appropriate model to forecast future observations of the time series.	5
CO6	Hypothesize real life problems and analyze those using appropriate inferential techniques.	6

	Title of Experiment / Practical
1.	Multiple Regression
2.	Multiple Regression verification using R
3.	Time Series-I
4.	Time Series-II
5.	Continuous probability distributions
6.	Model Sampling from Continuous probability distributions, verification using R
7.	Computations of probabilities using R
8.	Fitting of Normal distribution, verification using R
9.	Large sample tests of hypothesis
10.	Small sample tests of hypothesis
11.	Non-parametric tests
12.	Tests using R
13, 14 and 15.	Applications of statistical techniques to real life data.

References:

1. Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1989.

2. Fundamentals of Applied Statistics (4th Edition), Gupta and Kapoor, S. Chand and Sons, New Delhi, 2014.

3. A First course in Probability 6th Edition, Ross, Pearson Publication, 2006.

4. Statistics Using R, S.G.Purohit, S.D.Gore, S. R. Deshmukh, Narosa Publishing House, 2018

5. Common Statistical Tests, Kulkarni M.B., Ghatpande S.B., Gore S.D., Satyajeet Prakashan, Pune, 1999.

F. Y. B. A. Semester-II		
STS-1112	**Introduction to Descriptive Statistics-II** **(Minor-Theory)**	**Credits:04** **Hours : 60**
	Course Outcomes (COs) **On completion of the course, the students will be able to:**	**Bloom's cognitive level**
CO1	Describe the concept of bivariate data, index numbers.	1
CO2	Compute Karl Pearson's coefficient of correlation and Spearman's rank correlation coefficient and obtain lines and curves of regression.	2
CO3	Apply method of least squares in estimation of parameters.	3
CO4	Differentiate between correlation and regression.	4
CO5	Consider and justify the use of correlation and regression.	5
CO6	Construct price and quantity indices	6
Unit No	**Title and Contents**	**No. of Lectures**
I	**Correlation:** 1.1 Bivariate data, Scatter diagram and interpretation. 1.2 Concept of correlation between two variables, positive correlation, negative correlation, 1.1 Covariance between two variables (m_{11}), Definition, computation, effect of change of origin and scale. 1.2 Karl Pearson's coefficient of correlation (r): Definition, computation for ungrouped data and interpretation. Properties: (i) $-1 \leq r \leq 1$ (without proof), (ii) Effect of change of origin and scale (without proof). 1.5 Spearman's rank correlation coefficient: Definition, derivation of formula, computation and interpretation (without ties). In case of ties, compute Karl Pearson's correlation coefficient between ranks. (Spearman's rank correlation coefficient formula with correction for ties not expected.)	**(13)**
II	**Linear Regression Model:** 2.1 Meaning of regression, difference between correlation and regression, 2.2 Concept of error in regression, error modelled as a continuous random variable. Simple linear regression model: $Y = a + b X + \varepsilon$, where ε is a continuous random variable with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$. Estimation of a, b by the method of least squares. Interpretation of parameters. Statement of the estimator of σ^2. 2.3 Concept of residual, (plot of residual against X,) residual plot concept of coefficient of determination.	**(10)**

III	**Fitting of curves to the bivariate data** : 3.1 Fitting of second degree curve ($Y = a + b X + c X^2$), 3.2 Fitting of exponential curves of the type $Y = a\ b^X$ and $Y = aX^b$. Estimation of parameters by method of least squares.	**(9)**
IV	**Theory of Attributes** 4.1 Attributes: Concept of a Likert scale, classification, notion of manifold classification, dichotomy, class-frequency, order of a class, positive class- frequency, negative class frequency, ultimate class frequency, relationship among different class frequencies (up to three attributes), and dot operator to find the relation between frequencies, fundamental set of class frequencies. 4.2 Consistency of data upto 2 attributes. 4.3 Concepts of independence and association of two attributes. 4.4 Yule's coefficient of association (Q), $-1 \le Q \le 1$ interpretation.	**(13)**

V	**Time Series**
	 5.1 Meaning of Time Series
	 5.2 Various components of a time series (Explanation and illustrations of each component)
	 5.3 Additive and Multiplicative methods for analysis of a time series
	 5.4 Methods of estimating trends
	     (i) Freehand or Graphical method
	     (ii) Method of semi-averages
	     (iii) Method of moving averages
	     (iv) Method of least squares
	 5.5 Simple numerical problems.
		(15)

References:
1. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, New Delhi.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.
3. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.
4. Freund, J. E. (1977). Modern Elementary Statistics. Fourth Edition, Prentice Hall of India Private Limited, New Delhi.
5. Sarma, K. V. S. (2001). Statistics Made It Simple: Do it yourself on PC. Prentice Hall of India, New   Delhi.
6. Snedecor G. W. and Cochran W. G. (1989). Statistical Methods, Eighth Ed. East- West Press.