



**Fergusson College (Autonomous)**  
**Pune**

**Learning Outcomes-Based Curriculum**

**for**

**F. Y. B. Sc. Statistics**

**With effect from June 2019**

<b>Program Outcomes (POs) for B.Sc. Programme</b>	
<b>PO1</b>	<b>Disciplinary Knowledge:</b> Demonstrate comprehensive knowledge of the disciplines that form a part of an graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
<b>PO2</b>	<b>Critical Thinking and Problem solving:</b> Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
<b>PO3</b>	<b>Social competence:</b> Display the understanding, behavioural skills needed for successful social adaptation , work in groups, exhibits thoughts and ideas effectively in writing and orally.
<b>PO4</b>	<b>Research-related skills and Scientific temper:</b> 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.
<b>PO5</b>	<b>Trans-disciplinary knowledge:</b> Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
<b>PO6</b>	<b>Personal and professional competence:</b> 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.
<b>PO7</b>	<b>Effective Citizenship and Ethics:</b> 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.
<b>PO8</b>	<b>Environment and Sustainability:</b> Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
<b>PO9</b>	<b>Self-directed and Life-long learning:</b> Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	<b>Program Specific Outcomes(PSOs)</b>  <b>Upon completion of this programme the student will be able to</b>
<b>PSO1</b>	<b>Academic competence:</b> (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.
<b>PSO2</b>	<b>Personal and Professional Competence:</b> (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.
<b>PSO3</b>	<b>Research Competence</b> (i) 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.
<b>PSO4</b>	<b>Entrepreneurial and Social competence:</b> (i) Learn and apply stochastic processes, concept of regression, optimization techniques , survival analysis, reliability theory in real life situations.

## Programme Structure

Year	Course Code	Title	Paper No.	Credits
<b>F.Y. B.Sc.</b>	<b>Semester I</b>			
	STS1101	Descriptive Statistics	I	2
	STS1102	Probability Theory	II	2
	STS1103	Statistics Practical - I	III	2
	STS1201	Basic Applied Statistics	I	2
	<b>Semester II</b>			
	STS1202	Probability Distributions	II	2
	STS1203	Statistics Practical - II	III	2
<b>S.Y. B.Sc.</b>	<b>Semester III</b>			
	STS2301	Discrete Probability Distributions II and Introduction to SAS ( Software)	I	2
	STS2302	Continuous Probability Distributions - I	II	2
	STS2303	Practicals - III	III	2
	<b>Semester IV</b>			
	STS2401	Statistical Inferential Methods, Related Computing Tool (R- Software)	I	2
	STS2402	Continuous Probability Distribution - II	II	2
	STS2403	Practicals - III	III	2
<b>T.Y. B.Sc.</b>	<b>Semester V</b>			
	STS3501	Distribution Theory	I	3
	STS3502	Theory of Estimation	II	3
	STS3503	Introduction to Regression Analysis	III	3
	STS3504	Design of Experiments	IV	3
	STS3505	Actuarial Statistics	Elective - I } <b>Any One</b>	3
	STS3506	Operations Research		3
	STS 3507	Statistics Practical – I	Elective - III } <b>Any One</b>	3
	STS3508	Statistics Practical – II		3
	STS3509	Statistics Practical – III	Practical - I	2
	STS3511	Data Analysis using C-programming	Practical - II	2
	STS3512	Data Analysis using R software	Practical - III	2

Year	Course Code	Title	Paper No.	Credits
<b>T.Y. B.Sc.</b>	<b>Semester VI</b>			
	STS3601	Introduction to Stochastic Processes	I	3
	STS3602	Testing of Hypotheses	II	3
	STS3603	Reliability and Survival Analysis	III	3
	STS3604	Applied Multivariate Analysis	IV	3
	STS3605	Time Series Analysis	Elective - I <b>Any One</b>	3
	STS3606	Biostatistics		3
	STS 3607	Statistics Practical – I	Elective - II <b>Any One</b>	3
	STS3608	Statistics Practical – II		3
	STS3609	Statistics Practical – III	Practical - IV	2
	STS3611	Elements of Statistical Computing and Data mining	Practical - V	2
	STS3612	Statistical Computing using R software	Project	2

F.Y. B.Sc. Semester I		
Title of the Course and Course Code	Descriptive Statistics STS1101	Number of Credits : 02
<b>Course Outcomes (COs)</b> <b>On completion of the course, the students will be able to:</b>		
CO1	Recall the concepts of statistical population and sample.	
CO2	Articulate the data and its type and summarize information in the data using different summary measures.	
CO3	Apply methods and procedures of summarizing information in real life situations in various fields.	
CO4	Analyze the bivariate quantitative data.	
CO5	Judge and make comparisons through the exploratory data analysis and summary measures.	
CO6	Organize and summarize the information by suitable presentations and computations.	

**Objectives:**

The main objective of this course is to acquaint students with some basic concepts in Statistics. They will be introduced to some elementary statistical methods of analysis of data

- (i) to compute various measures of central tendency, dispersion, skewness and kurtosis and also using R.
- (ii) to compute the correlation coefficient for bivariate data and interpret it and also using R.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<b>Introduction to Statistics</b> Meaning of Statistics as a science, Importance of Statistics., <b>Scope of Statistics:</b> In the field of Industry, Biological sciences, Medical sciences, Economics, Social sciences, Management sciences, Agriculture, Insurance, Information Technology, Education and Psychology, Statistical organizations in India and their functions: CSO, ISI, NSSO, IIPS, Bureau of Economics and Statistics.	02
II	<b>Population and Sample</b> Types of characteristics: Attributes: Nominal scale, ordinal scale, Likert scale, Variables: Interval scale, ratio scale discrete and continuous variables. Types of data: Primary data, Secondary data, Cross-sectional data, Time series data, Directional data. Notion of a statistical population and sample: Finite population, infinite population, homogeneous population and heterogeneous population. sample and a random sample. 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.	05

	Inclusion probabilities, Use of R for Sampling.	
III	<p><b>Summary Statistics</b></p> <p>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.</p> <p><b>Measures of Central Tendency</b></p> <p>Concept of central tendency of statistical data, Statistical averages, characteristics of a good statistical average.</p> <p>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.</p> <p>Mode and Median: Definition, merits and demerits. Empirical relation between mean, median and mode.</p> <p>Partition values: Quartiles, Deciles and Percentiles.</p> <p>Geometric Mean (G.M.): Definition, merits and demerits.</p> <p>Harmonic Mean (H.M.): Definition, merits and demerits.</p> <p>Order relation between arithmetic mean, geometric mean, harmonic mean.</p> <p>Weighted Mean: weighted A.M., G.M. and H.M.</p> <p>Situations where one kind of average is preferable to others.</p> <p><b>Measures of Dispersion</b></p> <p>Concept of dispersion, characteristics of good measure of dispersion.</p> <p>Range, Semi-interquartile range (Quartile deviation): Definition, merits and demerits.</p> <p>Mean deviation: Definition, merits and demerits, minimality property (without proof)</p> <p>Variance and standard deviation: Definition, merits and demerits, effect of change of origin and scale, combined variance for n groups (derivation for two groups).</p> <p>Mean squared deviation: Definition, minimality property of mean squared deviation, Measures of dispersion for comparison:</p> <p>Coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.). Examples and problems (also using R).</p>	12
IV	<p><b>Moments, Skewness and Kurtosis</b></p> <p>Moments: Raw moments (<math>m'_r</math>) for ungrouped and grouped data. Central moments (<math>m_r</math>) for ungrouped and grouped data, Effect of change of origin and scale. Relations between central moments and raw moments upto 4<sup>th</sup> order (with proof).</p> <p>Concept of skewness of frequency distribution, positive skewness, negative skewness, symmetric frequency distribution and its relation with central tendency.</p> <p>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.</p> <p>Measures of Skewness based on moments (<math>\beta_1, \gamma_1</math>).</p> <p>Concepts of kurtosis, Types of kurtosis: Leptokurtic, Mesokurtic and Platykurtic frequency distributions and its relation with dispersion.</p>	07

	Measures of kurtosis based on moments ( $\beta_2, \gamma_2$ ). Properties of $\beta_1$ and $\beta_2$ (i) $\beta_2 \geq 1$ (ii) $\beta_2 \geq \beta_1 + 1$ Examples and problems (also using R)	
<b>V</b>	<b>Correlation</b>  Bivariate data, Scatter diagram and interpretation.  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 (r) : 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. 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.) Examples and problems (also using R)	10



**References:**

1. Agarwal, B. L. (2003). Programmed Statistics, 2<sup>nd</sup> 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, 6<sup>th</sup> Revised Edition, The World Press Pvt. Ltd., Calcutta.
4. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3<sup>rd</sup> Edition, Sultan Chand and Sons Publishers, New Delhi.
5. Krzanowski (2007). Statistical Principles 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. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.
9. Rastogi (2015). Biostatistics, 3<sup>rd</sup> Edition, Publisher Medtec
10. Robert S. Witte, John S. Witte (2017). Statistics, Publisher: Wiley
11. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers (1998). Probability and Statistics for Engineers and Scientists, Publisher, Prentice Hall.
12. Snedecor G. W. and Cochran W. G. (1989). Statistical Methods, Eighth Ed. East-West Press.

Wayne (2004). Biostatistics, 7<sup>th</sup> edition, Publisher: Wiley.

**Links:**

<https://mahades.mamardashtra.gov.in>

[www.mospi.gov.in](http://www.mospi.gov.in)

<http://www.isical.ac.in>

<https://iipsindia.org>

Title of the Course and Course Code	Probability Theory STS1102	Number of Credits : 02
<b>Course Outcomes (COs)</b> <b>On completion of the course, the students will be able to:</b>		
CO1	Describe random and non-random experiments.	
CO2	Articulate sample space for a certain random experiment and identify events and their types.	
CO3	Illustrate different real life situations to find probability of different types of events, the theorems of probability.	
CO4	Explain definition of independence of events to determine whether an assumption of independence is justifiable.	
CO5	Justify random variable(s) of interest in a given scenario and find the probability distribution.	
CO6	Formulate different discrete probability distributions based on finite sample space.	

**Objectives:** To introduce to students

- (i) the basic concepts of probability, axiomatic approach of probability, concept of independence of two events, conditional probability.
- (iii) the concept of random variable and univariate probability distribution.
- (iv) the concept of independence of study variables involved.
- (iv) standard discrete probability distributions based on finite sample space.

Unit. No	Title of Unit and Contents	No. of Lectures
I	<b>Review of probability, conditional probability, independence</b> Experiments / Models, deterministic and non- deterministic models. random experiment, concept of statistical regularity. 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. 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. Axiomatic definition of probability, theorems of probability, computation of probability of an event Conditional probability of an event. 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. Examples and problems.	09
II	<b>Bayes' Theorem</b> Partition of the sample space. Proof of Bayes' theorem, Applications of Bayes' theorem in real life. Examples and Problems.	03
III	<b>Univariate Probability Distributions</b> Concept and definition of a discrete random variable. Probability mass function (p.m.f.) and distribution function (d.f.),	12

	<p><math>F_X(\cdot)</math>, of discrete random variable, properties of distribution function.</p> <p>Mode and median of a univariate discrete probability distribution.</p> <p>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.</p> <p>Definitions of variance, properties of variance, standard deviation (s.d.) and coefficient of variation (c.v.) of univariate probability distribution</p> <p>Definition of raw, central moments and factorial raw moments of univariate probability distributions and their interrelations.</p> <p>Coefficients of skewness and kurtosis based on moments.</p> <p>Examples and Problems.</p>	
IV	<p><b>Discrete Probability Distributions based on finite sample space</b></p> <p>Degenerate distribution (one point distribution)</p> <p>Pmf: <math>P(X=c) = 1</math>, mean and variance.</p> <p>Uniform discrete distribution on integers 1 to n:</p> $\text{p.m.f. } P(X=x) = \begin{cases} \frac{1}{n} & , x = 1, 2, \dots, n. \\ 0 & \text{otherwise.} \end{cases}$ <p>mean, variance.</p> <p>variance, real life situations, comments on mode and median.</p> <p>Bernoulli distribution: p.m.f.</p> $P(X=x) = \begin{cases} p^x(1-p)^{1-x} & , x = 0, 1 \\ 0 & 0 < p < 1 \\ & \text{otherwise} \end{cases}$ <p>mean, variance and moments.</p> <p>Binomial distribution: p.m.f.</p> $P(X=x) = \begin{cases} \binom{n}{x} p^x q^{(n-x)} & , x = 0, 1, \dots, n. \\ & , 0 < p < 1, q = 1 - p \\ 0 & \text{otherwise.} \end{cases}$ <p>Notation: <math>X \sim B(n, p)</math>. , situations where this distribution is applicable.</p> <p>mean, variance, recurrence relation for successive probabilities,</p> <p>computation of probabilities of different events, mode of</p>	12

	<p>the distribution, m.g.f., c.g.f., moments, skewness (comments when <math>p = 0.5</math>, <math>p &gt; 0.5</math>, <math>p &lt; 0.5</math>), additive property.</p> <p>Hypergeometric Distribution: p.m.f</p> $P(X = x) = \begin{cases} \frac{\binom{M}{x} \binom{N-M}{n-x}}{\binom{N}{n}}, & x = 0, 1, \dots, \min\{n, M\}, N > M \\ 0 & \text{otherwise} \end{cases}$ <p>Notation : <math>X \sim H(N, M, n)</math>, situations where this distribution is applicable</p> <p>mean and variance, binomial approximation to hypergeometric distribution. Computation of probability, Examples and problems(also using R).</p>	
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#### References:

1. Agarwal B. L. (2003). Programmed Statistics, 2<sup>nd</sup> 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.
5. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, 3<sup>rd</sup> edition, McGraw Hill Book Company.
6. Ross S. (2002). A First Course in Probability, 6<sup>th</sup> edition, Pearson Education, Inc. & Dorling Kindersley Publishing, Inc.
7. Roussas, George G. (2016). First course in mathematical statistics. 2<sup>nd</sup> edition Publisher: Academic Press.
8. Walpole and Myres, (1986). Mathematical Statistics, 4<sup>th</sup> edition, Publisher: Longman Higher Education.

<b>Title of the Course and Course Code</b>	<b>Statistics Practical - I STS1103</b>	<b>Number of Credits : 02</b>
<b>Course Outcomes (COs)</b> <b>On completion of the course, the students will be able to:</b>		
CO1	Recall various graphical and diagrammatic techniques and interpret.	
CO2	Compute various measures of central tendency, dispersion, skewness and kurtosis.	
CO3	Calculate and determine correlation coefficient of bivariate data.	
CO4	Analyze the data using R- Software.	
CO5	Evaluate probabilities of univariate distributions.	
CO6	Develop summary statistics of output generated by R-Software.	

<b>Sr. No.</b>	<b>Pre-requisites: Knowledge of the topics in theory papers I and II.</b>
	<b>Title of Experiment / Practical</b>
1	Diagrammatic and graphical representation, (also using R)
2	Measures of central tendency and measures of dispersion for ungrouped data, (also using R)
3	Measures of central tendency and measures of dispersion for grouped data, (also using R)
4	Measures of skewness and kurtosis, (also using R)
5	Random sampling and summary statistics,(also using R)
6	Correlation for ungrouped and grouped data, (also using R)
7	Univariate Probability Distributions ( Finding of probability distribution through experimentation)
8	Fitting of binomial distribution , (also using R)
9	Application of binomial and hypergeometric distribution, (also using R)
10	Survey and its analysis

F.Y. B.Sc. Semester II		
Title of the Course and Course Code	Basic Applied Statistics (STS1201)	Number of Credits : 02
<b>Course Outcomes (COs)</b> <b>On completion of the course, the students will be able to:</b>		
CO1	Recall concept of bivariate and multivariate data, correlation, Karl Pearson's correlation coefficient and its interpretation.	
CO2	Explain simple, multiple regression models, fitting of second degree and exponential curves, computation of price, quantity indices and study of qualitative data.	
CO3	Apply appropriate statistical models to data generated in day to day life by using R software and calculate various price and quantity indices and Yule's coefficient of association.	
CO4	Identify the situations for simple linear and multiple linear regression models.	
CO5	Compare fitted models on the basis of residual analysis and coefficient of determination.	
CO6	Formulate the real-life situations in terms of regression analysis.	

**Objectives:**

The main objective of this course is to acquaint students with some concepts in Statistics. They will be introduced to some statistical methods of analysis of data:

- i) Fitting linear regression model to the bivariate data.
- ii) Fitting second degree and exponential curves to bivariate data.
- iii) Studying multiple partial correlation and fitting multiple linear regression to trivariate data.
- iv) computing various index numbers and their interpretation.
- v) studying qualitative data.

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<b>Regression</b> Meaning of regression, difference between correlation and regression. Concept of error in regression, error modeled as a continuous random variable. Simple linear regression model: $Y = a + bX + \epsilon$ , where $\epsilon$ is a continuous random variable with $E(\epsilon) = 0$ , $V(\epsilon) = \sigma^2$ . Estimation of a, b by the method of least squares. Interpretation of parameters. Statement of the estimator of $\sigma^2$ .  Concept of residual, plot of residual against X, concept of coefficient of determination.	07

	Examples and problems (also using R)	
II	<p><b>Curve fitting</b></p> <p>Fitting of second degree curve (<math>Y = a + bX + cX^2</math>),</p> <p>Fitting of exponential curves of the type <math>Y = ab^X</math> and <math>Y = aX^b</math>.</p> <p>In all these curves, parameters are estimated by the method of least squares.</p> <p>Examples and problem (also using R)</p>	05
III	<p><b>Multiple Linear Regression Model (tri-variate case)</b></p> <p>Concept of tri-variate data</p> <p>Definition of multiple correlation coefficient <math>R_{Y \cdot X_1 X_2}</math></p> <p>Derivation of the expression for the multiple correlation coefficient. Properties of multiple correlation coefficient (statement only)</p> <p>(i) <math>0 \leq R_{Y \cdot X_1 X_2} \leq 1</math></p> <p>(ii) <math>R_{Y \cdot X_1 X_2} &gt; \min \{ r_{YX_1}, r_{YX_2} \}</math></p> <p>Interpretation of coefficient of multiple determination <math>R_{Y \cdot X_1 X_2}^2</math></p> <p>(i) <math>R_{Y \cdot X_1 X_2}^2 = 1</math></p> <p>(ii) <math>R_{Y \cdot X_1 X_2}^2 = 0</math></p> <p>Definition of partial correlation coefficient <math>r_{YX_1 \cdot X_2}, r_{YX_2 \cdot X_1}</math></p> <p>Notion of multiple linear regression</p> <p>Multiple linear regression model</p> $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots + \beta_k X_k + \epsilon,$ <p>where <math>\epsilon</math> is a continuous random variable with <math>E(\epsilon) = 0</math>, <math>V(\epsilon) = \sigma^2</math>.</p> <p>Fitting of regression plane of Y on <math>X_1</math> and <math>X_2</math>, <math>Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon</math>, by the method of least squares; obtaining normal equations, solutions of normal equations</p> <p>Residuals: definition, derivation of variance of residual, properties of residuals (statement only)</p> <p>Definition and interpretation of partial regression coefficients <math>b_{YX_1 \cdot X_2}, b_{YX_2 \cdot X_1}</math></p> <p>Properties of partial correlation and regression coefficient (statement only)</p> <p>(i) <math>-1 \leq r_{YX_1 \cdot X_2} \leq 1</math> and <math>-1 \leq r_{YX_2 \cdot X_1} \leq 1</math></p> <p>(ii) <math>b_{YX_1 \cdot X_2} \cdot b_{YX_2 \cdot X_1} = r_{YX_1 \cdot X_2}^2</math></p> <p>Examples and problem (also using R)</p>	08

IV	<p><b>Index Numbers</b>  Introduction of index numbers, Definition and meaning, Problems/considerations in the construction of index Numbers, Simple and weighted price index numbers based on price relatives, Simple and weighted index numbers based on aggregates, Laspeyre's, Paasche's and Fisher's Index numbers. Time reversal Test, factor reversal test, circular test, Consumer price index number: Considerations in its construction.</p> <p>Methods of construction of consumer price index number:  (i) Family budget method (ii) Aggregate expenditure method. Shifting of base, splicing, deflating, purchasing power. Description of the BSE sensitivity and similar index numbers. Examples and problem (also using R)</p>	08
V	<p><b>Theory of Attributes</b>  Attributes: 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.</p> <p>Consistency of data upto 3 attributes, Concepts of independence and association of two attributes.</p> <p>Yule's coefficient of association (Q), <math>-1 \leq Q \leq 1</math>, interpretation.  Examples and problems</p>	08

**References:**

- 1 Agarwal, B. L. (2003). Programmed Statistics, 2<sup>nd</sup> edition, New Age International Publishers, New Delhi.
- 2 Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, 6<sup>th</sup> revised edition, The World Press Pvt. Ltd., Calcutta.
- 3 Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3<sup>rd</sup> edition, Sultan Chand and Sons Publishers, New Delhi.
- 4 Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.
- 5 Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentice Hall of India, New Delhi.
- 6 Lefebvre Mario (2006) Applied probability and Statistics, Publisher Springer.



Title of the Course and Course Code	Probability Distributions (STS1202)	Number of Credits : 02
<p align="center"><b>Course Outcomes (COs)</b>  <b>On completion of the course, the students will be able to:</b></p>		
CO1	Recall the concepts of discrete random variables.	
CO2	Extend the concept of discrete probability distributions to continuous probability distributions.	
CO3	Apply discrete distribution to real life situations.	
CO4	Identify different discrete probability distributions.	
CO5	Compare and illustrate the concept of two dimensional discrete random variables, bivariate and continuous probability distributions.	
CO6	Build the interrelations between the probability distributions.	

**Objectives:**

The main objective of this course is to acquaint students with:

- (i) The concept of two dimensional discrete random variables and bivariate probability distribution.
- (ii) Discrete probability distributions based on countably infinite sample space.
- (iii) Interrelations between these distributions.
- (iv) Introduction to continuous probability distributions

Unit. No.	Title of Unit and Contents	No. of Lectures
I	<p><b>Bivariate discrete probability distribution</b> (6L)</p> <p>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, Concepts of marginal and conditional probability distributions.</p> <p>Independence of two discrete random variables based on joint and marginal p.m.f, Definition of raw and central moments, 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. <math>\text{Var}(aX + bY)</math>.</p> <p>Examples and Problems, Illustrations of some standard bivariate probability distributions, Examples and problems</p>	11
II	<p><b>Multinomial distribution:</b> Probability mass function (p. m. f.)</p>	

	$P(X_1 = x_1, X_2 = x_2 \dots, X_k = x_k) = \frac{n!}{x_1! x_2! \dots x_k!} p_1^{x_1} p_2^{x_2} \dots p_k^{x_k}$ $x_1 + x_2 + \dots + x_k = n, \quad p_1 + p_2 + \dots + p_k = 1,$ $0 < p_i < 1, x_i = 0, 1, 2 \dots n, i = 1, 2, \dots, k$ $= 0 \quad \text{otherwise}$ <p>Notation:  <math>(X_1, X_2 \dots X_k) \sim MD(n, p_1, p_2 \dots p_k)</math>  <math>\underline{X} \sim MD(n, \underline{p})</math>  where <math>\underline{X} = (X_1, X_2 \dots X_k)</math>, <math>\underline{p} = (p_1, p_2 \dots p_k)</math></p> <p>Joint m.g.f. of <math>(X_1, X_2 \dots X_k)</math>, use of m.g.f. to obtain mean, variance, covariance, total correlation coefficients, multiple and partial correlation coefficients for <math>k = 3</math>.  Univariate marginal distribution of <math>X_i</math>, distribution of <math>X_i + X_j</math>, conditional distribution of <math>X_i</math> given <math>X_i + X_j = r</math>, variance - covariance matrix, rank of variance - covariance matrix and its interpretation, real life situations and applications.</p>	6
III	<p><b>Univariate discrete probability distributions based on countably infinite sample space.</b>  <b>Poisson distribution:</b> Notation : <math>X \sim P(\lambda)</math>.</p> $p(x) = \begin{cases} \frac{e^{-\lambda} \lambda^x}{x!}, & x = 0, 1, 2, \dots, \lambda > 0 \\ 0 & \text{otherwise} \end{cases}$ <p>Situations where this distribution is applicable.  Mean, variance and m.g.f, and c.g.f., moments using c.g.f., skewness, kurtosis, recurrence relation, conditional distribution <math>X   X + Y</math>, additive property, Poisson distribution as a limiting form of binomial distribution</p> <p><b>Geometric distribution:</b> Notation: <math>X \sim G(p)</math>,  Geometric distribution on support <math>(0, 1, 2, \dots)</math>,  with p.m.f. <math>p(x) = \begin{cases} pq^x, &amp; x = 0, 1, 2, \dots, 0 &lt; p &lt; 1, q = 1 - p. \\ 0 &amp; \text{otherwise} \end{cases}</math></p> <p>Geometric distribution on support <math>(1, 2, \dots)</math>  with p.m.f. <math>p(x) = \begin{cases} pq^{x-1}, &amp; x = 1, 2, \dots, 0 &lt; p &lt; 1, q = 1 - p. \\ 0 &amp; \text{otherwise} \end{cases}</math></p> <p>distribution function, recurrence relation, situations where this distribution is applicable.  mean, variance, m.g.f, c.g.f., moments, lack of memory property.</p> <p><b>Negative Binomial Distribution:</b>  p. m. f. :</p>	15

	$P(X = x) = \begin{cases} \binom{x+k-1}{x} p^k q^x & x = 0, 1, \dots \\ 0 & \text{otherwise.} \end{cases}$ <p> <math>k &gt; 0, 0 &lt; p &lt; 1, q = 1 - p</math> </p> <p> <b>Notation:</b> <math>X \sim \text{NB}(k, p)</math>.  <b>Nature of p. m. f., negative binomial distribution as a</b>          waiting time distribution, Situations where this distribution is applicable, mean, variance, m.g.f, c.g.f., moments, skewness and kurtosis, recurrence relation between probabilities, Poisson approximation to negative binomial distribution, negative binomial distribution as a sum of k i.i.d. geometric random variables.          Examples and problems (also using R)       </p>	
IV	<p><b>Introduction to univariate continuous probability distributions</b></p> <p>Continuous sample space: Definition, illustrations, Continuous random variable: Definition, probability density function (p.d.f.)</p> <p>Uniform or rectangular distribution: probability density function (p.d.f.)</p> $f(x) = \begin{cases} \frac{1}{b-a}, & a \leq x \leq b \\ 0 & \text{otherwise.} \end{cases}$ <p> <b>Notation:</b> <math>X \sim U[a, b]</math>          computation of probabilities          Normal distribution: probability density function (p. d. f.)       </p> $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2\sigma^2}(x - \mu)^2\right), \quad -\infty < x < \infty; -\infty < \mu < \infty; \sigma > 0$ <p> <b>Notation:</b> <math>X \sim N(\mu, \sigma^2)</math>          Identification of location and scale parameters, nature of probability curve          Exponential distribution: probability density function (p. d. f.)       </p> $f(x) = \begin{cases} \alpha e^{-\alpha x}, & x > 0, \alpha > 0 \\ 0 & \text{otherwise.} \end{cases}$ <p> <b>Notation :</b> <math>X \sim \text{Exp}(\alpha)</math>, computation of probabilities          Examples and problems (also using R)       </p>	4

**References:**

1. Agarwal B. L. (2003). Programmed Statistics, 2<sup>nd</sup> 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. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, 8<sup>th</sup> Edition, Sultan Chand and Sons Publishers, New Delhi.
4. Hogg, R. V. and Craig R. G. (1989). Introduction to Mathematical Statistics, MacMillan Publishing Co., New York.
5. Lefebvre Mario (2006) Applied probability and Statistics, Publisher Springer
6. Mayer, P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co., London.
7. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, 3<sup>rd</sup> edition, McGraw Hill Book Company.
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9. Rohatgi (2011). An Introduction to Probability and Statistics, Willey publications.
10. Ross S. (2002). A First Course in Probability, 6<sup>th</sup> edition, Pearson Education, Inc. & Dorling Kindersley Publishing, Inc.

Title of the Course and Course Code	Practical – II (STS1203)	Number of Credits : 02
<b>Course Outcomes (COs)</b> <b>On completion of the course, the students will be able to:</b>		
CO1	Recall the concepts of bivariate, multivariate data, correlation, Karl Pearson's correlation coefficient and its interpretation.	
CO2	Explain simple, multiple regression models, fitting of second degree and exponential curves.	
CO3	Compute price, quantity indices and probabilities of discrete distributions.	
CO4	Analyze different types of indices.	
CO5	Compare fitted models based on residual analysis and coefficient of determination.	
CO6	Construct cost of living index number for real life situations.	

<b>Sr. No.</b>	<b>Pre-requisites:</b> Knowledge of the topics in theory papers I and II.
	<b>Title of Experiment / Practical</b>
1	Simple linear regression ungrouped and grouped (also using R).
2	Fitting of second degree curve and exponential curve(also using R).
3	Fitting of Poisson distribution and finding expected frequencies(also using R).
4	Application of Poisson and multinomial distribution(also using R), model sampling
5	Fitting of geometric and negative binomial distribution and finding expected frequencies(also using R).
6	Applications of geometric, negative binomial distributions(also using R).
7	Index numbers.
8	Computation of multiple and partial correlation coefficient (also using R).
9	Fitting of multiple regression plane (also using R).
10	Bivariate probability distribution