



**Maharashtra Education Society's**

**ABASAHEB GARWARE COLLEGE, PUNE**

**(AUTONOMOUS)**

*(Affiliated to Savitribai Phule Pune University)*

**Three year B.Sc. Degree Program in Statistics  
(Faculty of Science and Technology)**

**Syllabi under Autonomy  
F.Y.B.Sc. (Statistics)**

**Choice Based Credit System Syllabus  
To be implemented from Academic Year 2022-2023**

## **Title of the Course: F.Y.B.Sc. (Statistics)**

### **Preamble**

Statistics as a subject is an important branch of knowledge and is devoted to various techniques of collection, presentation, analysis and interpretation of data. The usage of the word Statistics changes as the contexts changes. In every situation Statistics refers to quantitative data in the area under study for example, to a cricket fan, Statistics is the information about runs scored or wickets taken by a player. To the manager of a manufacturing unit, Statistics may be the information about the process control. To a medical researcher investigating the effects of a new drug.

Statistics are evidence of research efforts. It is a science of learning from data. Statistics provides tools for making decisions under uncertainty. Hence tools and techniques of Statistics are used in almost all fields. Statistics is indispensable in fields like agriculture, business, management, economics, finance, insurance, education, biotechnology and medical science etc. With the help of computers large amount of data can be handled and more sophisticated statistical techniques can be used in an effective manner. Knowledge of different aspects of Statistics has become crucial, since there is a continuous demand for statisticians in every field.

The syllabus of the three Year B. Sc. degree course in Statistics is framed in such a way that the students at the end of the course will be equipped to judiciously apply the statistical tools to a variety of data sets to arrive at meaningful conclusions. Statistics can be divided into two broad categories, (1) exploratory statistics or descriptive statistics, which is concerned with summarizing data and describing these data, and (2) confirmatory statistics or inferential statistics, which is concerned with making decisions about the population based on the sample. Techniques of descriptive statistics are briefly reviewed in the first year of under-graduation, but emphasis in degree course is on inferential statistics.

At first year of under-graduation, students will be given the basic information that includes – methods of data representation and summarization. Correlation and regression are the forecasting tools that are frequently used in statistical analysis. These topics are studied in one of the papers in each semester. Introduction to population studies will be

initiated through basics of Demography. Further they are introduced to probability and different discrete probability distributions along with their applications. Relevant experiments on these topics will be included in practical course. Further the students are expected start using some statistical software and verify the computations during practicals. It is a skill oriented part of the course.

**Program Outcomes:**

1. To familiarize students with elementary techniques of data analysis - graphical and numerical.
2. To introduce students to measures of central tendency and dispersion, and hence enable them to infer about the nature and characteristics of a particular dataset.
3. To acquaint students with the concept and significance of Index Numbers.
4. To introduce to the students the basic concepts of probability, axiomatic theory of probability, concept of random variable, univariate probability distribution, expectation and moments of probability distribution.
5. To compute the correlation coefficient for bivariate data and interpret it.
6. To fit linear and non-linear curves to the bivariate data to investigate relation between two variables.
7. To understand the concepts of demography.
8. To introduce students to some standard discrete univariate distributions, their properties and applications in real life.
9. To acquaint students with bivariate probability distributions with related concepts.
10. To summarize, analyze and interpret data through various techniques learnt by manual calculations as well as by using MS-Excel.

**Eligibility:** Higher Secondary School Certificate (10 + 2) examination with Mathematics as one of the subject.

**Structure of the Course: B.Sc. Statistics**

Year	Semester	Course Type	Course Code	Course Title	Remark	Credit	No. of Lectures /Practicals to be conducted
FYBSc	I	Core Course	USST -111	Descriptive Statistics	Theory	2	36
			USST -112	Discrete Probability Distributions I	Theory	2	36
			USSTP -113	Practical Paper - I	Practical	1.5	09
	II	Core Course	USST -121	Bivariate Data Analysis and Demography	Theory	2	36
			USST -122	Discrete Probability Distributions II	Theory	2	36
			USSTP -123	Practical Paper - II	Practical	1.5	09
SYBSc	III	Core Course	USST -231	Probability Distributions-I	Theory	2	36
			USST -232	Probability Distributions-II	Theory	2	36
			USSTP -233	Practical Paper - I	Practical	2	12
		Ability Enhancement courses	USLG-231	Language	Theory	2	36
			UEVS-231	Environmental Science	Theory	2	36
	IV	Core Course	USST -241	Statistical Methods	Theory	2	36
			USST -242	Sampling distributions and their applications	Theory	2	36
			USSTP -243	Practical Paper - II	Practical	2	12
		Ability Enhancement courses	USLG-241	Language	Theory	2	36
			UEVS-241	Environmental Science	Theory	2	36

Year	Semester	Course Type	Course Code	Course Title	Remark	Credit	No. of Lectures /Practical to be conducted
TYBSc	V	Core Courses	USST-351	Distribution Theory	Theory	2	36
			USST-352	Theory of Estimation	Theory	2	36
			USST-353	Design and Analysis of Experiments	Theory	2	36
			USST-354	Operations Research – I	Theory	2	36
		Discipline Specific Elective Courses	USSTELE-355(A) OR USSTELE-355(B)	Stochastic Processes OR Reliability Theory and Applications	Theory (Choose any one)	2	36
		Core Courses	USST-356	Regression Analysis	Theory	2	36
			USSTP-357	Practical Paper – I	Practical	2	12
			USSTP-358	Practical Paper – II	Practical	2	12
			USSTP-359	Practical Paper – III	Practical	2	12
		Skill Enhancement Courses	USSTSEC-3510	Introduction to Python	Theory	2	36
			USSTSEC-3511	Statistical Computing using R-software	Theory	2	36
	VI	Core Courses	USST-361	Sampling Theory	Theory	2	36
			USST-362	Testing of Hypothesis	Theory	2	36
			USST-363	Statistical Process and Product Control	Theory	2	36
			USST-364	Time Series Analysis	Theory	2	36
		Discipline Specific Elective Courses	USSTELE-365(A) OR USSTELE-365(B)	Introduction to Survival Analysis OR Computational Statistics and Resampling	Theory (Choose any one)	2	36
			USSTELE-366(A) OR USSTELE-366(B)	Operations Research – II OR Biostatistics	Theory (Choose any one)	2	36

F.Y.B.Sc. (Statistics)

		Core Courses	USSTP-367	Practical Paper – I	Practical	2	12
			USSTP-368	Practical Paper – II	Practical	2	12
			USSTP-369	Project	Practical	2	12
		Skill Enhancement Courses	USSTSEC-3610	Advanced Python	Theory	2	36
			USSTSEC-3611	Data Analytics	Theory	2	36

**SEMESTER-I****Course Code and Title: USST-111 - Descriptive Statistics****Lectures: 36 (Credits: 2)****Course Outcomes:**

By the end of the course, students should be able to:

1. Identify the appropriate scale of measurement for a particular characteristic under study.
2. Represent data using appropriate diagram/graph.
3. Calculate and describe data through measures of central tendency and dispersion.
4. Interpret the utilization of measures of central tendency and dispersion to compare group results.
5. Calculate and aptly interpret coefficients of skewness and kurtosis.
6. Assess relationship between two attributes.
7. Compute and interpret Index Numbers.

Unit Number	Content		No. of Lectures
1	<b>Introduction to Statistics</b>		2
	1.1	Meaning, importance and scope in various fields, viz. Industry, Biological sciences, Medical sciences, Economics, Social Sciences, Insurance, Management sciences, Agriculture, Information technology, Education and Psychology.	
	1.2	Statistical organizations in India and their functions.	
	1.3	Statistical Heritage (Indian Perspective: Prof. P.C. Mahalanobis, Prof. P. V. Sukhatme, Prof. V. S. Huzurbazar, and Prof. C. R. Rao).	
2	<b>Types of Data and Population and Sample</b>		5
	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: Primary data, Secondary data, Time Series data, Cross-sectional data, Directional data, Survival data, Longitudinal data, Panel 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 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.	
3	<b>Summary Statistics</b>		<b>12</b>
	3.1	Classification of raw data: Ungrouped and Grouped Frequency distributions, inclusive and exclusive methods of classification, open ended classes, class limits and boundaries, frequency density, relative frequencies.	
	3.2	3.2 (a) Central tendency (average) and its Measures, requisites of a good average, computation and interpretation with merits and demerits of the following for ungrouped and grouped data: Arithmetic Mean (A.M.), Geometric Mean (G.M.), Harmonic Mean (H.M.) - unweighted and weighted. Trimmed arithmetic mean. Mode. Median. 3.2 (b) Combined arithmetic mean for two or more groups. 3.2 (c) Partition Values - Quartiles, Deciles and Percentiles. 3.2 (d) Empirical relationship between Mean, Median and Mode. 3.2 (e) Ordered relationship between A.M., G.M. and H.M. (Proof for two observations only), Situations where a particular average is applicable, Change of origin and scale for A.M. (Statement and interpretation/uses only).	
	3.3	3.3 (a) Dispersion and its Measures: Requisites of a good measure of dispersion, Computation of measures (for grouped and ungrouped data) and interpretation with merits and demerits, absolute and relative measures: Range and coefficient of range. Quartile deviation (semi-interquartile range) and coefficient of quartile deviation. Mean deviation about averages and corresponding coefficients of mean deviation. Mean square deviation. Variance and standard deviation.	

		<p>Coefficient of Variation (C.V.).</p> <p>3.3 (b) Combined variance and standard deviation for two or more groups.</p> <p>3.3 (c) Properties of measures of dispersion: Minimality property of mean deviation and mean square deviation (both with proof), Change of scale and origin for variance (Statement and interpretation/uses only), Use of relative measures for comparison of two or more datasets.</p>	
	3.4	Five number summary and construction of Boxplot.	
4	<b>Skewness and Kurtosis</b>		6
	4.1	Notion of Moments: Raw moments ( $m'_r$ ) and Central moments ( $m_r$ ) (For ungrouped and grouped data), Relationship between raw and central moments (up to fourth order, with proof).	
	4.2	Concept of symmetry and skewness, types of skewness, assessing skewness from boxplots, coefficients of skewness with interpretation: Karl Pearson's coefficient of skewness, Bowley's coefficient of skewness and its range, Pearsonian ( $\gamma_1$ ) coefficient of skewness, comparison of datasets with respect to type and extent of skewness.	
	4.3	Concept of kurtosis, types of kurtosis, Pearsonian coefficient of kurtosis ( $\gamma_2$ ), and its interpretation.	
	4.4	Conditions for consistency of data in terms of Pearsonian coefficients - ( $\beta_1 \geq 1, \beta_2 \geq \beta_1 + 1$ ), Statement and examples.	
5	<b>Attributes</b>		6
	5.1	Notion of classification - dichotomous and manifold, class frequencies and their categories, method of dot operator for relationships between class frequencies (two and three attributes), Concept and applications of Likert Scale.	
	5.2	Consistency of data (upto two attributes), Concepts of association and independence, assessing independence using class frequencies, Yule's coefficient of association ( $Q$ ) and its interpretation, range of the coefficient of association ( $Q$ ).	
6	<b>Index Number</b>		5
	6.1	Introduction and scope of Index Numbers, Definition and Meaning of Index Numbers.	
	6.2	Problems/ Considerations in the construction of Index Numbers.	

6.3	Simple and weighted Price Index Numbers based on price relatives and aggregates.
6.4	Laspeyre's, Paasche's and Fisher's Index Numbers, Cost of Living Index Number.
6.5	Shifting of base, splicing.

**References:**

1. Brase C. H., Brase C. P (2016). Understandable Statistics, Concepts and Methods, 12<sup>th</sup> Edition, Cengage Learning.
2. Freedman D., Pisani R., Purves R. (2007). Statistics, 4<sup>th</sup> Edition, W. W. Norton and Company.
3. Freund J. E. (1977). Modern Elementary Statistics. 4th Edition, Prentice Hall of India Private Limited, New Delhi.
4. Goon A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1. 6th Revised Edition, The World Press Pvt. Ltd., Calcutta.
5. Gupta S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics. 8th Edition, Sultan Chand and Sons Publishers, New Delhi.
6. Gupta S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3rd Edition, Sultan Chand and Sons Publishers, New Delhi.
7. Heumann C., Schomaker, M., Shalabh (2016). Introduction to Statistics and Data Analysis. 1st Edition, Springer, Germany.
8. Moore D. S., Notz W. I., Fligner M. A. (2013). The Basic Practice of Statistics, 6<sup>th</sup> Edition, Ruth Baruth.
9. Utts J. M., Heckard R. F. (2010). Mind On Statistics, 4<sup>th</sup> Edition, Richard Stratton Publisher.
10. Zealure C. H. (1998). Fundamentals of Descriptive Statistics. 1st Edition, Routledge, U.K. (Taylor and Francis Group).

**Course Code and Title: USST-112 - Discrete Probability Distributions I****Lectures: 36 (Credits: 2)****Course Outcomes:**

By the end of the course, students should be able to:

1. Students will get familiarized with basic concepts of random experiment, random variable, probability, etc.
2. Students will get idea regarding a use of probability in real life situations. Also students can find out probability of real life events.
3. Students will able to identify the nature of data using moments, skewness, kurtosis, etc.
4. Students will able to see the dependency of events using probability or conditional probability.
5. Students will able to apply standard discrete probability distribution to different real situations.

Unit Number	Content	No. of lectures
1	<b>Probability</b> 1.1 Experiments, Ideas of deterministic and non-deterministic experiments. Random Experiment, concept of statistical regularity. 1.2 Definitions of - (i) Sample space, (ii) Discrete and Continuous sample space, (iii) Event, (iv) Elementary event, (v) Complement of an event, (vi) Certain event, (vii) Impossible event. 1.3 Concept of occurrence of an event. 1.4 Algebra of events and its representation in set theory notation. Occurrence of following events: at least one of the given events, none of the given events, all of the given events, mutually exclusive events, mutually exhaustive events, Exactly one event out of the given events. 1.5 Equiprobable and non-equiprobable sample space, Classical definition of probability and its limitations, Axiomatic definition of probability, Probability model, probability of an event. 1.6 Theorems and results on probability with proofs based on axiomatic definition such as, $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ Generalization $P(A \cup B \cup C), 0 \leq P(A) \leq 1$ , $P(A) + P(A') = 1, P(\Phi) = 0, P(A) \leq P(B)$ when $A \subset B$	6

	Boole's inequality. 1.7 Definition of probability in terms of odds. 1.8 Examples and problems.	
<b>2</b>	<b>Conditional Probability and Bayes' Theorem</b> 2.1 Independence of two events, Pairwise independence and mutual independence for three events. 2.2 Introduction to conditional probability of an event, definition. 2.3 Results on conditional probability. 2.4 Multiplication theorem for two and three events. 2.5 Partition of the sample space, prior and posterior probabilities. 2.6 Proof of Bayes' theorem. Applications of Bayes' theorem in real life. 2.7 Examples and problems.	<b>4</b>
<b>3</b>	<b>Univariate Probability Distributions (Defined on Discrete Sample Space)</b> 3.1 Random variable, Concept and definition of discrete random variable. 3.2 Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.), $F(\cdot)$ of discrete random variable, properties of c.d.f. 3.3 Mode and median of a univariate discrete probability distribution. 3.4 Examples and problems.	<b>4</b>
<b>4</b>	<b>Mathematical Expectation (Univariate Random Variable)</b> 4.1 Definition of mathematical expectation (Mean) of a random variable, expectation of a function of a random variable. 4.2 Definitions of variance, standard deviation (s.d.) and Coefficient of variation (c.v.) of univariate probability distribution, effect of change of origin and scale on mean, variance and s.d. 4.3 Definition of raw, central and factorial raw moments of univariate probability Distributions and their interrelations (without proof). 4.4 moment generating function (m.g.f.), cumulant generating function (c.g.f), probability generating function (p.g.f.) and their properties. 4.5 Coefficients of skewness and kurtosis based on moments. 4.6 Examples and problems.	<b>8</b>
<b>5</b>	<b>Some Standard Discrete Probability Distributions:</b> 5.1 Degenerate distribution (one point distribution): $P(X=c) = 1$ , mean and variance.	<b>14</b>

	<p>5.2 Uniform discrete distribution on integers 1 to n: p.m.f., c.d.f., mean, variance, real life situations, and comment on median.</p> <p>5.3 Bernoulli distribution: p.m.f., c.d.f, mean, variance, moments, skewness, kurtosis, m.g.f., c.g.f.</p> <p>5.4 Binomial Distribution: p.m.f.</p> $P(X = x) = \begin{cases} \binom{n}{x} p^x q^{n-x}, & x = 0, 1, 2, \dots, n; 0 < p < 1, q = 1 - p \\ 0, & \text{otherwise} \end{cases}$ <p>Notation: <math>X \sim B(n, p)</math></p> <p>Recurrence relation for successive probabilities, computation of probabilities of different events, mode of the distribution, mean, comments on median, variance, m.g.f., c.g.f, p.g.f., moments, skewness (comments when <math>p = 0.5</math>, <math>p &gt; 0.5</math>, <math>p &lt; 0.5</math>), kurtosis. Situations where this distribution is applicable, Additive property for binomial distribution, Conditional distribution of X given (X+Y) for binomial distribution.</p> <p>5.5 Hypergeometric Distribution: Necessity and importance of Hypergeometric distribution, capture-recapture method, p.m.f. of the distribution,</p> $P(X = x) = \begin{cases} \frac{\binom{M}{x} \binom{N-M}{n-x}}{\binom{N}{n}}, & x = 0, 1, 2, \dots, \min(M, n) \\ 0, & \text{otherwise} \end{cases}$ <p>Notation : <math>X \sim H(N, M, n)</math>.</p> <p>Computation of probability, situations where this distribution is applicable, mean and variance of the distribution, binomial approximation to hypergeometric probabilities.</p> <p>5.6 Examples and problems.</p>	
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**References:**

1. Agarwal B. L. (2003). Programmed Statistics, 2nd edition, New Age International Publishers, New Delhi.
2. Brase C. H., Brace C. P (2016). Understandable Statistics, Concepts and Methods, 12<sup>th</sup> Edition, Cengage Learning.

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5. Hoel P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
6. Hogg R. V. and Craig R.G.(1989).Introduction to Mathematical Statistics, MacMillan Publishing Co., New York.
7. Mayer P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co., London.
8. Mood A. M., Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, 3<sup>rd</sup> Edition, McGraw Hill Book Company.
9. Moore D. S., Notz W. I., Fligner M. A. (2013). The Basic Practice of Statistics, 6<sup>th</sup> Edition, Ruth Baruth.
10. Rao BLS Prakasa (2008). First Course in Probability and Statistics, New Age International Publishers, New Delhi
11. Rohatgi V. K. and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, John Wiley & Sons, Inc., Canada.
12. Ross S. (2002). A First Course in Probability, 6<sup>th</sup> Edition, Pearson Education, Inc.& Dorling Kindersley Publishing, Inc.
13. Utts J. M., Heckard R. F. (2010). Mind On Statistics, 4<sup>th</sup> Edition, Richard Stratton Publisher.

**Course Code and Title: USSTP-113 –Practical Paper I****(Credits: 1.5)****Course Outcomes:**

By the end of the course, students should be able to:

1. Use various graphical and diagrammatic techniques to represent statistical data and interpret.
2. Analyze data pertaining to discrete variables and to interpret the results.
3. Compute various measures of central tendency, dispersion, skewness and kurtosis.
4. Interpret summary statistics obtained using MS-Excel spreadsheet.
5. Summarize and analyze the data using MS-Excel.

Sr. No.	Title of the experiment
1.	Diagrammatic representation of statistical data: simple bar diagram, subdivided bar diagram, multiple bar diagram, percentage bar diagram, pie diagram, spike plot for Likert scale. Also using MS-Excel. Data interpretation from diagrams.
2.	Graphical representation of statistical data: Histogram, frequency curve and ogive curves, Pareto chart. Determination of mode and median graphically. Also using MS-Excel. Data interpretation from graphs.
3.	Use of random number tables to draw SRSWOR, SRSWR, stratified sample and systematic sample. Also using MS-Excel.
4.	Summary statistics – I: Computation of measures of central tendency and dispersion (ungrouped data). Use of an appropriate measure and interpretation of results and computation of partition values.
5.	Summary statistics – II: Computation of measures of central tendency and dispersion (grouped data). Use of an appropriate measure and interpretation of results and computation of partition values.
6.	Measures of skewness and kurtosis, Box plot.
7.	Computation of summary statistics, Creation of pivot table and frequency distributions using MS-Excel.
8.	Applications of Binomial and hypergeometric distributions. Computation of probabilities using MS-Excel.
9.	Index Numbers.

**Note:** Every practical is equivalent to four theory lectures per batch per week.

**SEMESTER-II****Course Code and Title:****USST-121 – Bivariate Data Analysis and Demography****Lectures: 36 (Credits: 2)****Course Outcomes:**

By the end of the course, students should be able to:

1. Identify the relationship between two variables.
2. Calculate and interpret correlation coefficient for bivariate data.
3. Identify the difference between linear and non-linear regression models.
4. Apply these methods to real life situations, draw valid conclusions and their interpretations.
5. To understand the concepts of demography.

<b>Unit Number</b>	<b>Content</b>	<b>No. of lectures</b>
<b>1</b>	<b>Correlation</b> 1.1 Bivariate data, Scatter diagram and its interpretation. 1.2 Concept of correlation between two variables. 1.3 Types of correlation (positive correlation, negative correlation, no correlation). 1.4 Covariance between two variables ( $m_{11}$ ): Definition, computation, effect of change of origin and scale. 1.5 Karl Pearson's coefficient of correlation ( $r$ ): Definition, computation for ungrouped data with interpretation. 1.6 Properties: $-1 \leq r \leq 1$ (with proof), Effect of change of origin and scale (with proof). 1.7 Spearman's rank correlation coefficient: Definition, 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). 1.8 Examples and problems.	<b>10</b>

2	<p><b>Regression</b></p> <p>2.1 Meaning of regression, Types of regression: linear and non-linear, difference between correlation and regression, connection between correlation and regression.</p> <p>2.2 Linear regression, Concept of error in regression, error modelled as a continuous random variable, Introduction to normal curve, Effect of change of parameters on curve.</p> <p>2.3 Simple linear regression model: <math>Y = a + bX + \varepsilon</math>, where <math>\varepsilon</math> is a continuous random variable with <math>E(\varepsilon)=0, V(\varepsilon) = \sigma^2</math>. Assumptions of regression model, Estimation of a, b by the method of least squares.</p> <p>Interpretation of parameters, Standard error of an estimate of line of regression, Explained and unexplained variation, concept of coefficient of determination.</p> <p>2.4 Estimation of <math>\sigma^2</math> (sum of squares due to error (S.S.E.)).</p> <p>2.5 Concept of residual, plot of residual against X, concept of missing data and outlier.</p> <p>2.6 Non-linear regression, Fitting of second degree curve (<math>Y = a + bX + cX^2</math>), Fitting of exponential curves of the type <math>Y = ab^X</math> and <math>Y = aX^b</math>.</p> <p>In all these curves constants or parameters are estimated by the method of least squares.</p> <p>2.7 Numerical problems related to real life situations.</p>	18
3	<p><b>Demography</b></p> <p>3.1 Vital events, vital statistics, methods of obtaining vital statistics, rates of vital events, sex ratios, dependency ratio.</p> <p>3.2 Death/Mortality rates: Crude death rates, specific (age, sex etc.) death rate, standardized death rate (direct and indirect), infant mortality rate.</p> <p>3.3 Fertility/Birth rate: Crude birth rates, general fertility rate, specific (age, sex etc.) fertility rates, total fertility rates.</p> <p>3.4 Growth/Reproduction rates: Gross reproduction rate, net reproduction rate.</p> <p>3.5 Interpretations of different rates, uses and applications. Trends in vital rates as per the latest census.</p>	8

**References:**

1. Agarwal B. L. (2003). Programmed Statistics, 2nd Edition, New Age International Publishers, New Delhi.
2. Brase C. H., Brace C. P (2016). Understandable Statistics, Concepts and Methods, 12th Edition, Cengage Learning.
3. Draper and Smith (1998). Applied Regression Analysis, John Wiley and Sons. Inc. 3rd edition.
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7. Gupta S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, 8th Edition, Sultan Chand and Sons Publishers, New Delhi.
8. Gupta S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3rd Edition, Sultan Chand and Sons Publishers, New Delhi.
9. Gupta S. P. (2014) Statistical Methods, 43<sup>rd</sup> Edition, Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
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13. Snedecor G. W. and Cochran W. G. (1989). Statistical Methods, 8th Edition East- West Press.
14. Utts J. M., Heckard R. F. (2010). Mind on Statistics, 4<sup>th</sup> Edition, Richard Stratton Publisher.

**Course Code and Title: USST-122 – Discrete Probability Distributions II****Lectures 36 (Credits: 2)****Course Outcomes:**

At the end this course, students are expected to be able:

1. To apply standard discrete probability distributions and their properties to different situations.
2. To work with two dimensional random variables and compute their probabilities.
3. To understand different properties of a bivariate probability distribution.
4. To compute covariance and correlation coefficient of bivariate random variables.

Unit Number	Content	No. of Lectures
<b>1</b>	<b>Discrete Probability Distributions</b> <b>1.1. Poisson distribution:</b> 1.1 (a): p.m.f. of the distribution: $P(X = x) = \frac{e^{-m} m^x}{x!}, x = 0, 1, 2, 3, \dots; m > 0$ $= 0, \text{ otherwise}$ Notation: $X \sim P(m)$ . 1.1 (b): Mean, variance, mode, moments, skewness, kurtosis, distribution function, m.g.f., c.g.f., p.g.f. 1.1 (c): ditive property for Poisson distribution. 1.1 (d): Recurrence relation of probabilities of Poisson distribution. 1.1 (e): Poisson distribution as a limiting case of Binomial Distribution. 1.1 (f): Conditional distribution of X given (X+Y) for Poisson distribution. 1.1 (g): Real life situations where this distribution is applicable, Examples.  <b>1. 2. Geometric distribution:</b> 1.2(a): Geometric distribution on support (0, 1, 2, ...) with p.m.f. $p(x) = pq^x$ . Notation: $X \sim G(p)$ . Mean, variance, comment on mode, distribution function, m.g.f., c.g.f., moments, skewness, kurtosis. 1.2(b): Geometric distribution on support (1, 2, ...) with p.m.f. $p(x) = pq^{x-1}$ . $0 < p < 1, q = 1 - p$ .	<b>17</b>

	<p>m.g.f., c.g.f., mean, variance and comment on mode.</p> <p>1.2(c): Lack of memory property.</p> <p>1.2(d): Conditional distribution of X given (X+Y) for Geometric distribution.</p> <p>1.2(e): Real life situations where this distribution is applicable, Examples.</p>	
<b>2</b>	<p><b>Bivariate Discrete Probability Distribution:</b></p> <p>2.1: Definition of two-dimensional discrete random variable and Joint probability mass function (p.m.f.), concept of identical distributed random variables.</p> <p>2.2: Joint probability distribution function and its properties.</p> <p>2.3: Marginal probability distribution.</p> <p>2.4: Independence of two discrete random variables based on joint, marginal and conditional p.m.f.s.</p> <p>2.5: Conditional probability distribution.</p> <p>2.6: Computation of probabilities of events in bivariate probability distribution.</p> <p>2.7: Examples and problems.</p>	<b>6</b>
<b>3</b>	<p><b>Mathematical Expectation (on Bivariate Random Variable)</b></p> <p>3.1: Mathematical Expectation of a function in Bivariate distribution.</p> <p>3.2: Definition of raw and central moments, m.g.f and c.g.f. using moments.</p> <p>3.3: Theorems on expectations of sum and product of two jointly distributed random variables.</p> <p>3.4: Conditional expectation and conditional variance.</p> <p>3.5: Theorem I: <math>E(X) = E[E(X Y)]</math>  II: <math>V(X) = E[V(X Y)] + V[E(X Y)]</math></p> <p>3.6: Definitions of covariance and coefficient of correlation.</p> <p>3.7: Independence and uncorrelatedness of two variables.</p> <p>3.8: Variance of a linear combination of random variables: <math>\text{Var}(aX + bY)</math>.</p> <p>3.9: Examples and problems.</p>	<b>13</b>

**References:**

1. Agarwal B. L. (2003). Programmed Statistics, 2nd edition, New Age International Publishers, New Delhi.
2. Brase C. H., Brace C. P (2016). Understandable Statistics, Concepts and Methods, 12th Edition, Cengage Learning.
3. Freedman D., Pisani R., Purves R. (2007). Statistics, 4th Edition, W. W. Norton and Company.
4. Gupta S.C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, 8th Edition, Sultan Chand and Sons Publishers, New Delhi.
5. Hoel P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
6. Hogg R.V. and Craig R.G. (1989). Introduction to Mathematical Statistics, Ed. MacMillan Publishing Co., New York.
7. Mayer P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co. London.
8. 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.
9. Moore D. S., Notz W. I., Fligner M. A. (2013). The Basic Practice of Statistics, 6th Edition, Ruth Baruth.
10. Rohatgi V. K. and Saleh, A. K. (2015). An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons, Inc.
11. Ross S. (2002). A First Course in Probability, Sixth Edition, Pearson Education, Inc. & Dorling Kindersley Publishing, Inc.
12. Utts J. M., Heckard R. F. (2010). Mind On Statistics, 4th Edition, Richard Stratton Publisher.

**Course Code and Title: USSTP-123 –Practical Paper II****(Credits: 1.5)****Course Outcomes:**

Students will be able to

1. Compute coefficient of correlation and regression for given data and interpret.
2. Analyze data pertaining to discrete distributions and to interpret the results.
3. Analyze the data with respect to bivariate discrete distributions.
4. Fit a line of regression, second degree curve and exponential curve using MS-Excel.
5. To fit the discrete probability distributions for the given data.
6. To study the computation of probabilities of an event using MS-Excel.

Sr. No.	Title of the experiment	No. of Practicals
1	Scatter diagram, correlation coefficient (ungrouped data). Fitting of line of regression. Also using MS-excel.	1
2	Fitting of second degree curve, exponential curve of type $Y = ab^x$ , $Y = aX^b$ . Also using MS-excel.	1
3	Fitting of Binomial and Poisson distribution and computation of expected frequencies, identification of median (Binomial distribution), Plot of observed and expected frequencies.	1
4	Applications of Poisson and Geometric distributions. Computation of probabilities using MS-excel.	1
5	Model sampling from Binomial and Poisson distributions.	1
6	Computation of fertility, mortality, and reproduction rates.	1
7	Bivariate Probability Distributions.	1
8	Project	2
<b>Total Practicals</b>		<b>09</b>

**Note:**

1. Every practical is equivalent to four theory lectures per batch per week.
2. For project, a group of maximum eight students to be made.
3. All the students in a group will be given equal marks for project report.
4. Different data sets from newspapers, internet, and magazines may be collected and students will be asked to use Statistical techniques/tools which they have learnt.

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