Fergusson College (Autonomous)

Pune

Learning Outcomes-Based Curriculum

for

F. Y. B. Sc. Statistics

With effect from June 2019

Course Structure for Statistics

Semester	Course Code	Title	Paper No.	Credits
I	STS1101	Descriptive Statistics	I	2
	STS1102	Probability Theory	II	2
	STS1103	Statistics Practical - I	III	2
II	STS1201	Basic Applied Statistics	I	2
	STS1202	Probability Distributions	II	2
	STS1203	Statistics Practical - II	III	2
III	STS2301	Discrete Probability Distributions II and Introduction to SAS (Software)	I	2
	STS2302	Continuous Probability Distributions - I	II	2
	STS2303	Practicals - III	III	2
IV	STS2401	Statistical Inferential Methods, Related Computing Tool (R- Software)	I	2
	STS2402	Continuous Probability Distribution - II	II	2
	STS2403	Practicals - III	III	2
V	STS3501	Distribution Theory	I	3
	STS3502	Theory of Estimation	II	3
	STS3503	Introduction to Regression Analysis	III	3
	STS3504	Designs of Experiments	IV	3
	STS3505	Actuarial Statistics	Elective - I } **Any One**	3
	STS3506	Demography & Indian official Statistics	Elective - II Paper - V	3
	STS3507	Operations Research	Elective - III } **Any One**	3
	STS3508	Biostatistics	Elective - IV Paper - VI	3
	STS3511	Statistical Analysis using C Programming	Practical - I	2
	STS3512	Statistical Analysis using R – I	Practical - II	2
	STS3513	Statistical Analysis using R – II	Practical - III	2
VI	STS3601	Introduction to Stochastic Processes	I	3
	STS3602	Testing of Hypotheses	II	3

Semester	Course Code	Title	Paper No.	Credits
	STS3603	Reliability and Survival Analysis	III	3
	STS3604	Sampling Methods	IV	3
	STS3605	Time Series Analysis	Elective - I } **Any One** Elective - II Paper - V	3
	STS3606	Statistical Ecology		3
	STS3607	Elements of Statistical computing and Data Mining	Elective - III } **Any One** Elective - IV Paper - VI	3
	STS3608	Statistical Quality Control		3
	STS3611	Statistics Practical – IV	Practical - IV	2
	STS3612	Statistics Practical – V	Practical - V	2
	STS3613	Statistics Practical –VI (Project)	Project	2

Programme Outcomes:

PO1	A student should be able to display knowledge of summary of data, graphical representation, correlation, regression and state important facts resulting from real life situations.
PO2	A student should get a relational understanding of Statistical concepts such as random experiments, random variable and probability distributions and use modelling techniques in the areas of Industries, Agriculture, Economics, Psychology etc. to analyse them.
PO3	Students should be able to apply their skills and knowledge to summarize information presented verbally or numerically into Statistical form, select and use appropriate Statistical techniques in order to process the information to draw appropriate conclusions.
PO4	A student should be made aware of history of Statistics and hence of its past, present and future role as part of our culture.
PO5	A student should be able to use **R software** to apply statistical techniques for summary of data, graphical representation, correlation, regression and be able to interpret their results from the analysis of real life situations.

PAPER CODE: STS1101
PAPER - I: Descriptive Statistics
[Credits - 2C]

Course outcomes	Suggested Pedagogy
This course imparts the knowledge about summary measures, correlation between two variables. By learning this course students will be able to apply these methods to real life situations, draw valid conclusions and their interpretations.	Black Board Teaching and problem-solving assignments Case studies and small project based learning of these topics

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.

	Title and Contents	**No. of Lectures**
Unit - 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, Biological sciences, Medical sciences, Economics, Social sciences, Management sciences, Agriculture, Insurance, Information Technology, Education and Psychology. 1.4 Statistical organizations in India and their functions: CSO, ISI, NSSO, IIPS, Bureau of Economics and Statistics.	**02**

Unit - II	**Population and Sample** 2.1 Types of characteristics: Attributes: Nominal scale, ordinal scale, Likert scale. Variables: Interval scale, ratio scale. discrete and continuous variables. 2.2 Types of data: (a) Primary data, Secondary data. (b) Cross-sectional data, Time series data, Directional data. 2.3 Notion of a statistical population and sample: Finite population, infinite population, homogeneous population and heterogeneous population. sample and a random sample. 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. 2.5 Inclusion probabilities. 2.6 Use of R for Sampling.	**05**
Unit - III	**Summary Statistics** 3.1 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. 3.2 **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. 3.3 **Measures of Dispersion** Concept of dispersion, characteristics of good measure of	**12**

	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. Measures of dispersion for comparison: Coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.). 3.4 Examples and problems (also using R).	
Unit - IV	**Moments, Skewness and Kurtosis** 4.1 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 4^{th} order (with proof). 4.2 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). 4.3 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). 4.4 Properties of β_1 and β_2 (i) $\beta_2 \geq 1$ (ii) $\beta_2 \geq \beta_1 + 1$ 4.5 Examples and problems (also using R)	**07**
Unit - V	**Correlation** 5.1 Bivariate data, Scatter diagram and interpretation. 5.2 Concept of correlation between two variables, positive correlation, negative correlation, no correlation. 5.3Covariance between two variables (m_{11}) : Definition, computation, effect of change of origin and scale.	**10**

	5.4 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. 5.5 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.) 5.6 Examples and problems (also using R)	

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. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.
9. Rastogi (2015). Biostatistics, 3rd 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.
13. Wayne (2004). Biostatistics, 7th edition, Publisher: Wiley.

Links:
https://mahades. mamarashtra.gov.in
www.mospi.gov.in
http://www.isical.ac.in
https://iipsindia.org

PAPER CODE: STS1102
PAPER –II: Probability Theory
[Credits - 2C]

Course outcomes	Suggested Pedagogy
At the end of the course students are expected to (i) distinguish between random and non random experiments. (ii) study the concept of probability of event (iii) identify random variable(s) of interest in different real life situations and find probability distribution of these variables.	Black Board Teaching and problem-solving assignments Case studies and small project based learning of these topics

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.

	Title and Contents	**No. of Lectures**
Unit - I	**Review of 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. 1.3 Concept of occurrence of an event. 1.4 Algebra of events and its representation in set theory notation. 1.5 Classical definition of probability and its limitations. 1.6 Probability model, equiprobable and non-equiprobable sample space. 1.7 Axiomatic definition of probability, theorems of probability , computation of probability of an event 1.8 Conditional probability of an event. 1.9 Independence of two events. 1.10 Pair-wise independence and mutual independence for three events. 1.11 Multiplication theorem $P(A \cap B) = P(A) \cdot P(B\|A)$ and its generalization. 1.12 Examples and problems.	**09**

Unit - II	**Bayes' Theorem** 2.1 Partition of the sample space. 2.2 Proof of Bayes' theorem, Applications of Bayes' theorem in real life. 2.3 Examples and Problems.	**03**
Unit - III	**Univariate Probability Distributions** 3.1 Concept and definition of a discrete random variable. 3.2 Probability mass function (p.m.f.) and distribution function (d.f.), $F_X(\cdot)$, of discrete random variable, properties of distribution function. 3.3 Mode and median of a univariate discrete probability distribution. 3.4 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. 3.5 Definitions of variance, properties of variance, standard deviation (s.d.) and coefficient of variation (c.v.) of univariate probability distribution 3.6 Definition of raw, central moments and factorial raw moments of univariate probability distributions and their interrelations. 3.7 Coefficients of skewness and kurtosis based on moments. 3.8 Examples and Problems.	**12**
Unit - IV	**Discrete Probability Distributions based on finite sample space** 4.1 Degenerate distribution (one point distribution) Pmf: P(X=c) =1, mean and variance. 4.2 Uniform discrete distribution on integers 1 to n: p.m.f. $P(X=x) = \begin{cases} \frac{1}{n} & , x = 1, 2, \cdots, n. \\ 0 & \text{otherwise.} \end{cases}$ mean, variance. 4.3 Bernoulli distribution: p.m.f. $P(X = x) = \begin{cases} p^x (1-p)^{1-x} & , x = 0,1 \\ & 0 < p < 1 \\ 0 & \text{otherwise} \end{cases}$ mean, variance and moments. 4.4 Binomial distribution: p.m.f. P(X = x) =	**12**

$$\begin{cases} \binom{n}{x} p^x q^{(n-x)} & , x = 0, 1, \ldots, n. \\ & , 0 < p < 1 \quad , q = 1 - p \\ 0 & \text{otherwise.} \end{cases}$$

Notation : X ~ 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) =

$$\begin{cases} \dfrac{\binom{M}{x}\binom{N-M}{n-x}}{\binom{N}{n}} & , x = 0, 1, \cdots\cdots \min\{n, M\}, N > M \\ 0 & \text{otherwise} \end{cases}$$

Notation : X ~ H (N, M, n), situations where this distribution is applicable

mean and variance, binomial approximation to hypergeometric distribution. Computation of probability,

4.6 Examples and problems(also using R).

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.
5. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, 3rd edition, McGraw Hill Book Company.
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.

PAPER CODE: STS1103
PAPER –III: STATISTICS PRACTICAL - I
[Credits - 2C]

Course outcomes	Suggested Pedagogy
At the end of this course students are expected to be able (i) to use various graphical and diagrammatic techniques and interpret. (ii) to compute various measures of central tendency, dispersion, skewness and kurtosis. (iii) to compute correlation coefficient. (iv) to analyse data pertaining to discrete and continuous variables and to interpret the results, (v) to compute probabilities of univariate distributions, (vi) to interpret summary statistics of output generated by R -Software. (vii) to summarize and analyze the data using R-Software.	• Practical examples and problems solving • Case studies and small project based learning of these topics • Use of R - Software and programme coding of statistical techniques applied to the problems

	Pre-requisites: Knowledge of the topics in theory papers I and II.
	Title of Experiment / Practical
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

PAPER CODE: STS1201
PAPER – I: Basic Applied Statistics
[Credits - 2C]

Course outcomes	Suggested Pedagogy
This course imparts the knowledge about correlation and regression analysis for bivariate and multivariate data, index numbers and analysis of qualitative data. By learning this course students will be able to apply these methods to real life situations, draw valid conclusions and their interpretations.	Black Board Teaching and problem-solving assignments Case studies and small project based learning of these topics.

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.

	Title and Contents	**No. of Lectures**
Unit - I	**Regression** 1.1 Meaning of regression, difference between correlation and regression. 1.2 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. 1.3 Concept of residual, plot of residual against X, concept of coefficient of determination. 1.4 Examples and problems (also using R)	**07**
Unit - II	**Curve fitting** 2.1 Fitting of second degree curve ($Y = a + b X + cX^2$), 2.2 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.	**05**

	2.3 Examples and problem (also using R)	
Unit - III	**Multiple Linear Regression Model (tri-variate case)** 3.1 Concept of tri-variate data 3.2 Definition of multiple correlation coefficient $R_{Y\cdot X_1X_2}$ 3.3 Derivation of the expression for the multiple correlation coefficient. Properties of multiple correlation coefficient (statement only) (i) $0 \le R_{Y\cdot X_1X_2} \le 1$ (ii) $R_{Y.X_1X_2} > \min\{ r_{YX_1}, r_{YX_2} \}$ Interpretation of coefficient of multiple determination $R^2_{Y.X_1X_2}$ (i) $R^2_{Y.X_1X_2} = 1$ (ii) $R^2_{Y.X_1X_2} = 0$ 3.4 Definition of partial correlation coefficient $r_{YX_1.X_2}$, $r_{YX_2.X_1}$ 3.5 Notion of multiple linear regression 3.6 Multiple linear regression model $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_k X_k + \epsilon$, where ε is a continuous random variable with $E(\varepsilon)= 0$, $V(\varepsilon) = \sigma^2$. 3.7 Fitting of regression plane of Y on X_1 and X_2, $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \epsilon$, by the method of least squares; obtaining normal equations, solutions of normal equations 3.8 Residuals: definition, derivation of variance of residual , properties of residuals (statement only) 3.9 Definition and interpretation of partial regression coefficients $b_{YX_1\cdot X_2}$, $b_{YX_2\cdot X_1}$ 3.10 Properties of partial correlation and regression coefficient (statement only) (i) $-1 \le r_{YX_1\cdot X_2} \le 1$ and $-1 \le r_{YX_2\cdot X_1} \le 1$ (ii) $b_{YX_1\cdot X_2} \cdot b_{YX_2\cdot X_1} = r^2_{YX_1\cdot X_2}$ 3.11 Examples and problem (also using R)	**08**
Unit - IV	**Index Numbers** 4.1 Introduction of index numbers. 4.2 Definition and meaning. 4.3 Problems/considerations in the construction of index numbers. 4.4 Simple and weighted price index numbers based on price relatives.	**08**

	4.5 Simple and weighted index numbers based on aggregates. 4.6 Laspeyre's, Paasche's and Fisher's Index numbers. 4.7 Time reversal Test, factor reversal test, circular test. 4.8 Consumer price index number: Considerations in its construction. 4.9 Methods of construction of consumer price index number: (i) Family budget method (ii) Aggregate expenditure method. 4.10 Shifting of base, splicing, deflating, purchasing power. 4.11 Description of the BSE sensitivity and similar index numbers. 4.12 Examples and problem (also using R)	
Unit - V	**Theory of Attributes** 5.1 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. 5.2 Consistency of data upto 3 attributes. 5.3 Concepts of independence and association of two attributes. 5.4 Yule's coefficient of association (Q), $-1 \leq Q \leq 1$, interpretation. 5.5 Examples and problems	**08**

References:

1 Agarwal, B. L. (2003). Programmed Statistics, 2nd edition, New Age International Publishers, New Delhi.

2 Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, 6th revised edition, The World Press Pvt. Ltd., Calcutta.

3 Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, 3rd 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. Prentce Hall of India, New Delhi.

6. Lefebvre Mario (2006) Applied probability and Statistics, Publisher Springer.

PAPER CODE: STS1202

PAPER - II: Probability Distributions
[Credits - 2C]

Course outcomes	Suggested Pedagogy
This course imparts the knowledge about bivariate probability distributions theoretical concepts, multinomial distribution and its its applications in the real life, Univariate discrete probability distributions based on countably infinite sample space and their real life applications , introduction to univariate continuous probability distributions. By learning this course students will be able to identify random variable(s) of interest in different real life situations and find probability distribution of these variables.	• Black Board Teaching and problem-solving assignments • Case studies and small project based learning of these topics

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

(i) The concept of two dimensional discrete random variable 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

	Title and Contents	**No. of Lectures**
Unit - I	**Bivariate discrete probability distribution** 1.1 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. 1.2 Computation of probabilities of events in bivariate probability distribution. 1.3 Concepts of marginal and conditional probability distributions. 1.4 Independence of two discrete random variables based on joint and marginal p.m.f. 1.5 Definition of raw and central moments. 1.6 Theorems on expectations of sum and product of two jointly distributed random variables. 1.7 Conditional expectation. 1.8 Definitions of conditional mean and conditional variance. 1.9 Definition of covariance, coefficient of correlation, 1.10 Variance of linear combination of variables i.e. Var(aX + bY). 1.11 Examples and Problems.	**11**

	1.12 Illustrations of some standard bivariate probability distributions 1.13 Examples and problems	
Unit - II	**Multinomial distribution:** Probability mass function (p. m. f.) $P(X_1 = x_1, X_2 = x_2 \cdots, X_k = x_k) = \frac{n!}{x_1!, x_2! \cdots x_k!} p_1^{x_1} p_2^{x_2} \cdots p_k^{x_k}$, $x_1 + x_2 + \cdots x_k = n, \quad p_1 + p_2 + \cdots p_k = 1,$ $0 < p_i < 1, x_i = 0, 1, 2 \cdots n, i = 1,2, \cdots k$ = 0 otherwise Notation: $(X_1, X_2 \cdots X_k) \sim MD(n, p_1, p_2 \cdots p_k)$ $\underline{X} \sim MD(n, \underline{p})$ where $\underline{X} = (X_1, X_2 \cdots X_k)$, $\underline{p} = (p_1, p_2 \cdots p_k)$ Joint m.g.f. of $(X_1, X_2 \cdots X_k)$, use of m.g.f. to obtain mean , variance, covariance, total correlation coefficients, multiple and partial correlation coefficients for k = 3. Univariate marginal distribution of X_i, distribution of $X_i + X_j$, conditional distribution of X_i given $X_i + X_j = r$, variance - covariance matrix, rank of variance - covariance matrix and its interpretation , real life situations and applications.	**6**
Unit - III	**Univariate discrete probability distributions based on countably infinite sample space.** 3.1 **Poisson distribution**: Notation : $X \sim P(\lambda)$. $p(x) = \begin{cases} \frac{e^{-\lambda}\lambda^x}{x!}, & x = 0,1,2 \ldots\ldots, \ \lambda > 0 \\ 0 & \text{otherwise} \end{cases}$ 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 X | X + Y , additive property, Poisson distribution as a limiting form of binomial distribution 3.2 **Geometric distribution**: Notation: X ~ G(p), Geometric distribution on support (0, 1, 2…) , with p.m.f. $p(x) = \begin{cases} pq^x, & x = 0, 1, 2\ldots, 0 < p < 1, \ q = 1 - p. \\ 0 & \text{otherwise} \end{cases}$ Geometric distribution on support (1, 2,…….) with p.m.f. $p(x) = \begin{cases} pq^{x-1}, & x = 1, 2\ldots \quad 0 < p < 1, \ q = 1 - p. \\ 0 & \text{otherwise} \end{cases}$ distribution function, recurrence relation, situations where this distribution is applicable.	**15**

	mean, variance, m.g.f, c.g.f.,moments , lack of memory property. 3.3 **Negative Binomial Distribution**: p. m. f. : $$P(X=x) = \begin{cases} \binom{x+k-1}{x} p^k q^x & x = 0,1,\cdots\cdots \\ & k>0,\ 0<p<1,\ q=1-p \\ 0 & \text{otherwise.} \end{cases}$$ Notation**:** X ~ NB (k, p). Nature of p. m. f., negative binomial distribution as a 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. 3.4 Examples and problems (also using R)	
Unit - IV	**Introduction to univariate continuous probability distributions** 4.1 Continuous sample space: Definition, illustrations. 4.2 Continuous random variable: Definition, probability density function (p.d.f.) 4.3Uniform or rectangular distribution: probability density function (p.d.f.) $$f(x) = \begin{cases} \frac{1}{b-a}, & a \le x \le b \\ 0 & \text{otherwise.} \end{cases}$$ Notation : X ~ U[a, b] computation of probabilities 4.4 Normal distribution: probability density function (p. d. f.) $$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(\frac{-1}{2\sigma^2}(x-\mu)^2\right),\ -\infty < x < \infty ;-\infty < \mu < \infty ;\ \sigma > 0$$ Notation: X ~ N (μ ,σ^2) Identification of location and scale parameters, nature of probability curve 4.5 Exponential distribution: probability density function (p. d. f.) $$f(x) = \begin{cases} \alpha e^{-\alpha x}, & x > 0,\ \alpha > 0 \\ 0 & \text{otherwise.} \end{cases}$$	**4**

	Notation : $X \sim Exp(\alpha)$, computation of probabilities 4.6 Examples and problems (also using R)	
	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. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical 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, 3rd edition, McGraw Hill Book Company. 8. Mukhopadhyay P (2006) Mathematical Statistics Books & Allied (*P*) Ltd. 9. Rohatgi (2011). An Introduction to Probability and Statistics, Willey publications. 10. Ross S. (2002). A First Course in Probability, 6th edition, Pearson Education, Inc. & Dorling Kindersley Publishing, Inc.	

PAPER CODE: STS1203
PAPER – III: STATISTICS PRACTICAL - II
[Credits - 2C]

Course outcomes	Suggested Pedagogy
At the end of this course students are expected to be able i) to fit simple and multiple linear regression plane, curve fitting and compute multiple and partial correlation for the trivariate data ii) to fit Poisson, negative binomial and geometric distribution to the real life situations iii) to learn application of Poisson, negative binomial and geometric distribution to the real life situations iv) to compute index numbers v) to compute probabilities using R- Software vi) to fit regression line and plane using R- software	• Practical examples and problems solving • Case studies and small project based learning of these topics • Use of R - Software and programme coding of statistical techniques applied to the problems

	Pre-requisites: Knowledge of the topics in theory papers I and II.
	Title of Experiment / Practical
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