REVISED SYLLABUS
OF
S.Y.B.Sc. STATISTICS
(at subsidiary level)
With Effect from June 2009

STATISTICS

Notes :

1. A student of the three year B.Sc. degree course will not be allowed to offer **Statistics** and **Statistical Techniques** simultaneously in any of the three years of the course.
2. Students offering **Statistics** at the first year of the three year B.Sc. course may be allowed to offer **Statistical Techniques** as one of their subjects in the second year of the three year B.Sc. course in the place of Statistics.
3. Students offering **Statistical Techniques** at the first of the three year B.Sc. course may be allowed to offer **Statistics** as one of their subjects in the second year of the three year B.Sc. course in place of **Statistical Techniques** provided they satisfy other requirements regarding subject combinations, if any.
4. Students must complete all the practicals in each paper to the satisfaction of the teacher concerned.
5. Students must produce at the time of practical examination the laboratory journal along with the completion certificate signed by the Head of the Department.
6. Use of computer software whenever possible to be encouraged.
7. **Structure of evaluation of practical paper at S.Y.B.Sc.**

(A) Continuous internal evaluation	**Marks**
(i) Journal (ii) Viva-voce	10 10
Total	20

(B) Annual practical examination

Section	**Nature**	**Marks**	**Time**
I	On line examination : **Note :** Question is compulsory Q1 : MSEXCEL : Execute the commands and write the same in answer book alongwith answers	10	Maximum 15 minutes
II	Using Calculator **Note :** Attempt any two of the following **four** questions : Q2 : Q3 : Q4 : Q5 :	60 (30 marks for each question)	2 hours 45 minutes
III	Viva-voce	10	10 minutes
	Total B	80	3 Hours 10 minutes
	Total of A and B	100	–

Preparation by Internal Examiner for Section I : Online examination :

(1) Keep at least **4 computers** with latest configuration ready with **battery backup** and **necessary software** at the examination laboratory.

(2) Trivariate and bivariate data set of 10 to 20 items be fed in computer MSEXCEL spreadsheet before commencement of examination (Trivariate data set for multiple regression plane). Appropriate data set for time series : linear, quadratic, exponential trend fitting, exponential smoothings be entered in spreadsheet.

(3) Any other type of data required for time to time also be entered in computer spreadsheet.

Instructions to Examiners :

(1) Students are not expected to fill data items at the time of examination. They are expected to use MSEXCEL commands to operate on data set which are already fed.

(2) The question on section I are compulsory and there is no internal option.

(3) The commands of the nature attached in specimen are to be asked, so that the total marks of all asked commands will be exactly 10.

Objectives :

1. To fit varioius discrete and continuous probability distributions and to study various real life situations.
2. To identify the appropriate probability model, that can be used.
3. To use forecasting and data analysis techniques in case of univariate and multivariate data sets.
4. To use statistical software packages.
5. To test the hypotheses particularly about mean, variance, correlation, proportions, goodness of fit.
6. To study applications of statistics in the field of economics, demography etc.

SEMESTER – I, PAPER - I

S.T. – 211 DISCRETE PROBABILITY DISTRIBUTIONS AND TIME SERIES

Pre-requisite : Convergence of sequences and series.

1. Discrete Probability Distribution **(15 L)**

1.1 Countably infinite sample space : Definition, illustrations.

1.2 Random variable (r.v.) defined on infinite sample space, probability mass function (p.m.f.), cumulative distribution function (c.d.f.), properties of c.d.f. (without proof), median, mode, probabilities of events related to random variable.

1.3 Expectation of discrete r.v., expectation of function $g(\cdot)$ of r.v., application of the result to find raw moments and central moments (upto 4^{th} order), factorial moments (upto 2^{nd} order), Properties of expectation.

1.4 Bivariate discrete random variable or vector (X, Y) taking countably infinite values : Joint p.m.f., c.d.f., properties of c.d.f. without proof, marginal and conditional distributions, independence of two r.v.s. and its extension to several r.v.s., mathematical expectation.

Theorems of expectation : (i) $E(X + Y) = E(X) + E(Y)$, (ii) $E(XY) = E(X).E(Y)$ for independent r.v.s. and generalization of these theorems to k variables. Expectation of function of random vector $g(X, Y)$. Joint moments of order (r, s). Cov (X, Y), Corr (X, Y), Var $(aX + bY + c)$. Conditional expectations and variance, regression coefficient using conditional expectation if it is a linear function of conditioning variable. $E\,E(X|Y = y) = E(X)$.

1.5 Moment generating function (M.G.F.) : Definition, properties, theorems on MGF. (i) $M_x(0) = 1$, (ii) M.G.F. of $aX + b$, (iii) M.G.F. of $X + Y$ if X and Y are independent r.v.s. Generalization to sum of k variables, (iv) Uniqueness property (without proof).

Moments from M.G.F. using (i) expansion method, (ii) differentation method.

MGF of bivariate r.v. : Definition, M.G.F. of marginal distribution of r.v.s. properties (i) $M(t_1, t_2) = M(0, t_2)\, M(t_1, 0)$ if X and Y are independent r.v.s., (ii) $M_{X+Y}(t) = M_{X,\ Y}(t, t)$, (iii) $M_{X+Y}(t) = M_X(t) \cdot M_Y(t)$ if X and Y are independent.

1.6 Cumulant generating function (C.G.F.) : Definition, properties (i) effect of change of origin, (ii) additive property. Relation between cumulants and moments (upto order four).

2. Standard Discrete Distributions **(21 L)**

2.1 Poisson Distribution : Notation : $X \sim P(m)$.

P.m.f. : $P(X = x) = \dfrac{e^{-m}\, m^x}{x!}$, (support) $x = 0, 1, 2 \ldots ;\ m > 0$.

$= 0 \quad , \quad$ elsewhere

Nature of p.m.f. Moments, M.G.F., C.G.F., mean, variance, skewness, kurtosis, mode, additive property, recurrence relation between (i) raw moments (ii) central moments, conditional distribution of X given X + Y where X and Y are independent Poisson r.v.s. real life situations.

2.2 **Geometric Distribution : Notation :** $X \sim G(p)$,

P.m.f. : $P(X = x) = p\, q^x \quad , \quad x = 0, 1, 2, ...; \; 0 < p < 1, q = 1 - p$

$= 0 \quad , \quad$ otherwise

Nature of p.m.f. Mean, variance, distribution function, lack of memory property. Distribution of X + Y when X and Y are independent, distribution of min (X, Y) · (M.G.F., C.G.F. to be studied with negative binomial distribution). Alternative form of geometric distribution on support (1, 2, ...), real life situations.

2.3 **Negative Binomial Distribution : Notation :** X ~> NB (k, p).

P.m.f. : $P(X = x) = \binom{x + k - 1}{x} p^k q^x \quad , \quad x = 0, 1, 2 ....$

$0 < p < 1, \; q = 1 - p$

$= 0 \quad , \quad$ otherwise

Nature of p.m.f. negative binomial distribution as a waiting time distribution. M.G.F., C.G.F., mean, variance, skewness, kurtosis (recurrence relation between moments is not expected). Relation between geometric and negative binomial distribution. Poisson approximation to negative binomial distribution. real life situations.

3. Time Series : (8 L)

3.1 Meaning and utility of time series

3.2 Components of time series; trend, seasonal variations, cyclical variations, irregular (error) fluctuations or noise

3.3 Methods of trend estimation and smoothing : (i) moving average, (ii) curve fitting by least square principle, (iii) exponential smoothing.

3.4 Measurement of of seasonal variations.

(i) simple average method, (ii) ratio to moving averages method.

3.5 Fitting of autoregressive models AR (1) and AR (2), plotting of residuals.

4. Queueing Model : (4 L)

M/M/1 : FIFO as a application of exponential distribution, Poisson distribution and Geometric distribution :

Interarrival rate (λ) service rate (μ), traffic intensity ($\rho = \lambda/\mu < 1$), queue discipline, probability distribution of number of customers in queue, average queue length, average waiting time in (i) queue (ii) system.

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SEMESTER – I, PAPER – II

ST 212 : CONTINUOUS PROBABILITY DISTRIBUTIONS-I

Pre-requisite : Calculus of several variables, Maxima, Minima, Multiple integration.

1. Continuous Univariate Distributions : (12 L)

1.1 Continuous sample space : Definition, illustrations. Continuous random variable : Definition, probability density function (p.d.f.), cumulative distribution function (c.d.f.) properties of c.d.f. (without proof), probabilities of events related to r.v.

1.2 Expectation of continuous r.v., expectation of function of r.v. E[g(X)], mean, variance, geometric mean, harmonic mean, raw and central moments, skewness, kurtosis.

1.3 Moment generating function (M.G.F.) : Definition and properties, cumulant generating function, definition properties.

1.4 Mode, median, quartiles.

1.5 Probability distribution of transformation of r.v. : Y = g(X). Using

- (i) Jacobian of transformation for $g(\cdot)$ monotonic function and one-to-one, on to functions.
- (ii) Distribution function for $Y = X^2$, $Y = |X|$ etc.
- (iii) M.G.F. of g(X).

2. Continuous Bivariate Distributions (12 L)

2.1 Continuous bivariate random vector or variable (X, Y) : Joint p.d.f., joint c.d.f, properties (without proof), probabilities of events related to r.v. (events in terms of regions bounded by regular curves, circles, straight lines). Marginal and conditional distributions.

2.2 Expectation of r.v., expectation of function of r.v. E[g(X, Y)], joint moments, Cov (X, Y), Corr (X, Y), Conditional mean, conditional variance, $EE(X|Y = y) = E(X)$, regression as a conditional expectation if it is linear function of conditioning variable.

2.3 Independence of r.v. (X, Y) and its extension to k dimensional r.v. Theorems on expectation

(i) $E(X + Y) = E(X) + E(Y)$, (ii) $E(XY) = E(X)\cdot E(Y)$ if X and Y are independent, generalization to k variables. $E(aX + bY + c)$, $Var(aX + bY + c)$.

2.4 M.G.F. : $M_{X, Y}(t_1, t_2)$ properties, M.G.F. of marginal distribution of r.v.s. properties (i) $M_{X, Y}(t_1, t_2) = M_X(t_1, 0) \cdot M_Y(0, t_2)$ if X and Y are independent r.v.s.

(ii) $M_{X+Y}(t) = M_{X, Y}(t, t)$.

(iii) $M_{X+Y}(t) = M_X(t) \cdot M_Y(t)$ if X and Y are independent r.v.s.

2.5 Probability distribution of transformation of bivariate r.v.

$U = \phi_1(X, Y)$, $V = \phi_2(X, Y)$.

3. Standard Univariate Continuous Distributions (24 L)

3.1 **Uniform or Rectangular Distribution : Notation :** X ~> U(a, b)

p.d.f. $f(x) = \frac{1}{b-a}$, if $a \le x \le b$

$= 0$, otherwise

c.d.f., sketch of p.d.f., c.d.f., mean, variance, symmetry. Distribution of (i) $\frac{X-a}{b-a}$, (ii) $\frac{b-X}{b-a}$, (iii) Y = F(X), where F(X) is the c.d.f. of continuous r.v.X. Application of the result to model sampling. (Distributions of X + Y, X – Y, XY, $\frac{X}{Y}$ are not expected.)

3.2 Normal Distribution : Notation : $X \sim N(\mu, \sigma^2)$,

p.d.f. $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2\sigma^2}(x-\mu)^2}$, if $-\infty < x < \infty, -\infty < \mu < \infty, \sigma > 0$

$= 0$, otherwise

p.d.f. curve identification of scale and location parameters, nature of probability curve, mean, variance, M.G.F., CG.F., central moments, cumulants, β_1, β_2, γ_1, γ_2, median, mode, quartiles, mean deviation, additive property, computations of normal probabilities using, normal probability integral tables, probability distribution of (i) $\frac{X-\mu}{\sigma}$ standard normal variable (S.N.V.), (ii) aX + b, (iii) aX + bY + c, (iv) X^2 where X and Y are independent normal variates. Probability distribution of $\bar{X}$ the mean of n i.i.d. $N(\mu, \sigma^2)$ r.v.s. Normal probability plot, q-q plot to test normality. Simulation using Box-Muller transformation. Normal approximation to (i) binomial distribution, (ii) Poisson distribution applications of normal distribution. (iii) Statement of central limit theorem for i.i.d. r.v.s. with finite positive variance.

3.3 **Exponential Distribution : Notation :** $X \sim Exp(\alpha)$,

p.d.f. $f(x) = \alpha e^{-\alpha x}$, $x \ge 0, \alpha > 0$

$= 0$, otherwise

nature of p.d.f. curve, interpretation of α as rate and $1/\alpha$ as mean, mean variance, M.G.F., C.G.F., c.d.f., graph of c.d.f., lack of memory property, median, quartiles. Distribution of min (X, Y) with X, Y i.i.d. exponential r.v.s..

3.4 **Gamma Distribution : Notation :** $X \sim G(\alpha, \lambda)$.

$$\text{p.d.f.} \quad f(x) = \begin{cases} \dfrac{\alpha^{\lambda}}{\Gamma\lambda}\, e^{-\alpha x}\, x^{\lambda-1} & , \quad x \geq 0,\ \alpha > 0,\ \lambda > 0 \\ 0 & , \quad \text{otherwise} \end{cases}$$

Nature of probability curve, special cases (i) $\alpha = 1$, (ii) $\lambda = 1$, M.G.F., C.G.F., moment, cumulants, β_1, β_2, γ_1, γ_2, mode, additive property. Distribution of sum of n i.i.d. exponential variables. Relation between distribution function of Poisson and Gamma variates, Recurrence relation between moments.

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SEMESTER – II, PAPER – I

ST221 : STATISTICAL METHODS AND NATIONAL INCOME

1. Multiple Linear Regression and Multiple and Partial Correlation (for three variables) : **(18 L)**

1.1 Notion of multiple linear regression, Yule's notation (trivariate case – sample data only).

1.2 Fitting of regression planes by the method of least squares; obtaining normal equations, solutions of normal equations.

1.3 Residuals : Definition, order, properties, derivation of variance and covariances.

1.4 Definition and interpretation of partial regression coefficient $b_{ij.k}$, units of $b_{ij.k}$ definition of multiple correlation coefficient $R_{i.jk}$.

1.5 Derivation of the formula for the multiple correlation coefficient, also in terms of cofactors of correlation matrix.

1.6 Properties of multiple correlation coefficient (i) $0 \leq R_{i.jk} \leq 1$, (ii) $R_{i.jk} \geq r_{ij}$, $R_{i.jk} \geq r_{ik}$.

1.7 Interpretation of coefficient of multiple determination $R^2_{i.jk}$ as (i) proportion of variation explained by the linear regression (ii) $R_{i.jk} = 1$, (iii) $R_{i.jk} = 0$. Adjusted $R^2_{i.jk}$. Residual plots, problem of multicolinearity introduction, introduction to stepwise regression.

1.8 Definition of partial correlation coefficient $r_{ij.k}$.

1.9 Derivation of the formula for $r_{ij.k}$, also in terms of cofactors of correlation matrix.

1.10 Properties of partial correlation coefficient (i) $-1 \leq r_{i.j.k} \leq 1$, (ii) $b_{ij.k}\, b_{ji.k} = r^2_{ij.k}$.

Effect of partial correlation on regression estimate.

1.11 Introduction to odds ratio and logistic regression with one regressor.

2. Tests of Hypotheses **(15 L)**

2.1 Statistics and parameters, statistical inference : problem of estimation and testing of hypothesis. Estimator and estimate. Unbiased estimator (definition and illustrations only). Statistical hypothesis, null and alternative hypothesis, one sided and two sided alternative hypothesis, critical region, type I error, type II error, level of significance, p-value. Confidence interval.

2.2 Tests for mean of N (μ, σ^2), σ known, using critical region approach

(i) $H_0 : \mu = \mu_0$ $H_1 : \mu \neq \mu_0$, $H_1 : \mu > \mu_0$, $H_1 : \mu < \mu_0$

(ii) $H_0 : \mu_1 = \mu_2$, $H_1 : \mu_1 \neq \mu_2$, $H_1 : \mu_1 > \mu_2$, $H_1 : \mu_1 < \mu_2$

Confidence intervals for μ and $\mu_1 - \mu_2$.

2.3 **Test Based Normal Approximation (Approximate tests) :** Using central limit theorem (using critical region approach and p value approach)

Tests for proportion, P : Parameter in binomial distribution with very large n.

(i) $H_0 : P = P_0$, $H_1 : P \neq P_0$, $H_1 : P > P_0$, $H_1 : P < P_0$

(ii) $H_0 : P_1 = P_2$, $H_1 : P_1 \neq P_2$, $H_1 : P_1 > P_2$, $H_1 : P_1 < P_2$

Confidence intervals for P and $P_1 - P_2$.

2.4 Fisher's Z transformation : Necessity of transformation :

Approximate tests : Tests for correlation coefficient of bivariate normal distribution.

(i) $H_0 : \rho = \rho_0$, $H_1 : \rho \neq \rho_0$, $H_1 : \rho > \rho_0$, $H_1 : \rho < \rho_0$

(ii) $H_0 : \rho_1 = \rho_2$, $H_1 : \rho_1 \neq \rho_2$, $H_1 : \rho_1 > \rho_2$, $H_1 : \rho_1 < \rho_2$.

3. Index Numbers **(8 L)**

2.1 Consumers price index numbers : Considerations in its construction : (i) family budget method (ii) aggregate expenditure method.

2.2 Shifting of base, splicing, deflating, purchasing power.

2.3 Chain base index numbers and fixed base index numbers.

4. National Income **(7 L)**

4.1 Definition of national income by (i) Marshall, (ii) Pigou, (iii) Fisher.

4.2 Different concept of national income (a) gross national product (GNP), (b) net national product (NNP).

4.3 Personal income, disposable income, per capita income, gross domestic product (GDP), national income at market price, national income at factor cost, national income at current prices, national income at constant prices.

4.4 Methods of estimation of national income and the difficulties in methods.

(a) output method, (b) income method, (c) expenditure method.

4.5 Importance of national income.

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SEMESTER – II, PAPER - II

ST 222 : CONTINUOUS PROBABILITY DISTRIBUTIONS-II AND DEMOGRAPHY

1. Chi-square (χ^2) Distribution **(8 L)**

1.1 Definition of χ^2 r.v. as sum of squares of i.i.d. standard normal r.v., derivation of p.d.f. of χ^2 with n degrees of freedom (d.f.) using M.G.F., nature of p.d.f. curve, computations of probabilities using χ^2 tables, mean, variance, M.G.F., C.G.F., central moments, β_1, β_2, γ_1, γ_2, mode, additive property.

1.2 Normal approximation : (i) $\left(\frac{\chi^2 - n}{\sqrt{2n}}\right)$ with proof, (ii) Fisher's approximation : statement only. (Without proof)

1.3 Distribution of $\frac{\chi_1^2}{\chi_1^2 + \chi_2^2}$ and χ_1^2/χ_2^2 where χ_1^2 and χ_2^2 are two independent chi-square r.v.s.

2. Student's t-distribution **(5 L)**

2.1 Definition of t r.v. with n d.f. in the form

$$t = \frac{U}{\sqrt{\chi_n^2/n}}$$

where U ~ N(0, 1) and χ_n^2 is a χ^2 r.v. with n d.f. and U and χ_n^2 are independent r.v.s.

2.2 Derivation of p.d.f., nature of probability curve, mean, variance, moments, mode, use of t tables for calculation of probabilities, statement of normal approximation.

3. Snedecore's F-distribution **(5 L)**

3.1 Definition of F r.v. with n_1 and n_2 d.f. as $F_{n1,\ n2} = \frac{\chi_{n1}^2/n_1}{\chi_{n2}^2/n_2}$ where $\chi_{n_1}^2$ and $\chi_{n_2}^2$ are independent chi-square r.v.s with n_1 and n_2 d.f. respectively.

3.2 Derivation of p.d.f., nature of probabilities curve, mean, variance, moments, mode.

3.3 Distribution of $1/(F_{n1,n2})$, use of F-tables for calculation of probabilities.

3.4 Interrelations among, χ^2, t and F variaets.

4. Sampling Distributions **(5 L)**

4.1 Random sample from a distribution as i.i.d. r.v.s $X_1, X_2, ..., X_n$.

4.2 Notion of a statistic as function of $X_1, X_2, ..., X_n$ with illustrations.

4.3 Sampling distribution of a statistic. Distribution of sample mean $\overline{X}$ from normal, exponential and gamma distribution, Notion of standard error of a statistic.

4.4 Distribution of $\frac{nS^2}{\sigma^2} = \frac{1}{\sigma^2} \sum_{i=1}^{n} (X_i - \overline{X})^2$ for a sample from a normal distribution using orthogonal transformation. Independence of $\overline{X}$ and S^2.

5. Exact Tests based on χ^2, t and F distributions : (16 L)

5.1 Test for independence of two attributes arranged in 2×2 contingency table. (With Yates' correction).

5.2 Test for independence of two attributes arranged in $r \times s$ contingency table.

5.3 Test for 'Goodness of Fit'. Without rounding-off the expected frequencies.

5.4 Test for $H_0 : \sigma^2 = \sigma_0^2$ against one-sided and two-sided alternatives when (i) mean is known (ii) mean is unknown.

5.5 t-tests for population means : (i) one sample and two sample tests for one-sided and two-sided alternatives. (ii) $(1 - \alpha)$ 100% confidence interval for population mean (μ) and difference of means ($\mu_1 - \mu_2$) of two independent normal population and confidence interval of difference of means of two independent normal populations.

5.6 Paired t-test for one-sided and two-sided alternatives.

5.7 Test for correlation coefficient $H_0 : \rho = 0$, $H_0 : \rho_{i.jk} = 0$ against one-sided and two-sided alternatives. Using both t and F test (ANOVA).

5.8 Test for regression coefficient $H_0 : \beta = 0$ against one-sided and two-sided alternatives.

5.9 Test for $H_0 : \sigma_1^2 = \sigma_2^2$ against one-sided and two-sided alternatives when (i) means are known (ii) means are unknown.

6. Demorgraphy **(9 L)**

6.1 Vital events, vital statistics, methods of obtaining vital statistics, rates of vital events, sex ratios, dependency ratio.

6.2 Death/Mortality rates : Crude death rates, specific (age, sex etc.) death rate, standardized death rate (direct and indirect), infant mortality rate.

6.3 Fertility/Birth rate : Crude birth rates, general fertility rate, specific (age, sex etc.) fertility rates, total fertility rates.

6.4 Growth/Reproduction rates : Gross reproduction rate, net reproduction rate.

6.5 Interpretations of different rates, uses and applications.

6.6 Trends in vital rates due to the latest census.

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PAPER - III

ST 223 : PRACTICALS (Annual Examination)

Pre-requisites : Knowledge of the topics in theory.

Equipments : At least 4 computers latest configuration with necessary software, battery back up, printers, scientific calculators, necessary statistical tables.

Objectives :

1. To compute multiple and partial correlation coefficients, to fit trivariate multiple regression plane, to find residual s.s. and adjusted residual s.s. (using calculators and MSEXCEL).
2. To fit various discrete and continuous distributions, to test the goodness of fit, to draw model samples (using calculators and MSEXCEL).
3. To test various hypotheses included in theory.
4. To analyze time series data.
5. To determine demographic rates.

Sr. No.	Title of the experiment	No. of practicals
1.	Fitting Poisson distribution, testing goodness of fit	1
2.	Fitting negative binomial distribution, testing goodness of fit	1
3.	Model sampling from Poisson and geometric distribution	1
4.	Fitting of normal distribution, testing goodness of fit (also using qq plot)	1
5.	Applications of normal, Poisson, negative binomial distributions	2
6.	Model sampling from exponential, normal distribution using (i) distribution function, (ii) Box-Muller transformation.	1
7.	Fitting of trivariate regression plane given the correlation matrix. Computations of multiple, partial correlation coefficients, residual plot, adjusted R^2.	1
8.	Index numbers: cost of living index numbers	1
9.	Time series : Estimation of trend by fitting of AR (1) model	1

	exponential smoothing, moving averages.	
10.	Estimation of seasonal indices by ratio to trend and link relatives	1
11.	Demography	2

12.	Tests based of F distribution : $H_0 : \sigma_1^2 = \sigma_2^2$, $H_o : \rho = 0$, $H_0 : \rho_{1.23} = 0$ and also using t test. (In the form of ANOVA table)	1
13.	Test for means and construction of confidence interval (Normality to be checked using probability papers) **Also using MSEXCEL** (i) $H_0 : \mu = \mu_0$ σ known and σ unknown (ii) $H_0 : \mu_1 = \mu_2$ σ_1, σ_2 known (iii) $H_0 : \mu_1 = \mu_2$ $\sigma_1 = \sigma_2 = \sigma$ unknown, unpaired t test (iv) $H_0 : \mu_1 = \mu_2$ paired t test (v) $H_0 : \beta = \beta_0$	2
14.	Tests based on χ^2 distribution (i) goodness of fit (ii) independence of attributes(2×2, $m \times n$ contingency table) (iii) $H_0 : \sigma^2 = \sigma_0^2$ μ unknown, confidence interval for σ^2	1
15.	(a) Tests for proportions and construction of confidence interval $H_0 : P = P_0$, $H_0 : P_1 = P_2$ (b) Test for correlations $H_0 : \rho = \rho_0, H_0 : \rho_1 = \rho_2$	1
16.	Fitting of multiple regression plane using MSEXCEL	1
17.	Fitting of Poisson, normal distribution using MSEXCEL	1
18.	Computations of probabilities of Poisson, Normal, Exponential gamma, χ^2, t, F using MSEXCEL.	1
19.	Exponential smoothing using MSEXCEL	1
20.	**Project :** Practicals based on analysis of data collected by students in a batch of size not exceeding 12 students.	2

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Books recommended

1. Hogg, R. V. and Craig, A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Co. Inc. 866, Third Avenue, New York 10022.
2. Gupta, S. C. and Kapoor V. K. : Fundamentals of Mathematical Statistic, Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
3. Mood, A. M., Graybill F. A. and Boes, F. A. : (Chpaters II, IV, V, VI) Introduction to Theory of Statistics (Third Edition), McGraw – Hill Series G A 276, 1974.
4. Walpole R. E. and Mayer R. H. : Probability and Statistics (Chapter 4, 5, 6, 8, 10), Macmillan Publishing Co. Inc. 866, Third Avenue, New York 10022.
5. Arora Sanjay and Bansilal : New Mathematical Statistics : First Edition, Stya Prakashan, 16/7698 New Market, New Delhi – 5 (1989).
6. Medhi, J. : Statistical Methods, Wiley Eastern Ltd., 4835/24, Ansari Road, Daryaganj, New Delhi – 110002.
7. Mayer, P. L. : Introductory Probability and Statistical Applications, Addision Weseley Pub. Comp. London.
8. Kulkarni, M. B. Ghatpande, S. B. and Gore, S. D. : Common Statistical Tests Satyajeet Prakashan, Pune 411029 (1999).
9. Gupta, S. P. : Statistical Methods, Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
10. Mukhopadhya Parimal (1999) : Applied Statistics, New Central Book Agency, Pvt. Ltd. Calcutta.
11. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986) : Fundamentals of Statistics, Vol. 2, World Press, Calcutta.
12. Gupta, S. C. and Kapoor (V. K. (1987) : Fundamentals of Applied Statistics. S. Chand and Sons, New Delhi.
13. Sheldon Ross : A first course in probability : Pearson education publishers.
14. Neil Weiss : Introductory Statistics : Pearson education publishers.
15. M. K. Jhingan : Macro Economic Theory : Vrinda Publications Pvt. Ltd. New Delhi.
16. R. D. Gupta : Keynes Post – Keynesian Economics : Kalyani Publishers, New Delhi.
17. M. L. Sheth : Macro Economics : Lakshmi-Narayan Agarwal education publishers, Agra 3.
18. H. L. Ahuja : Modern Economics : S. Chand publishers, New Delhi.
