Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
Autonomous
Course Structure for T. Y. B. Sc. STATISTICS
(w. e. from June, 2021)

Semester	Paper Code	Title of Paper	No. of Credits
V	STAT3501	Distribution Theory	3
	STAT3502	Statistical Inference- I	3
	STAT3503	Sampling Methods	3
	STAT3504	Design of Experiments	3
	STAT3505	C- Programming	3
	STAT3506(A) STAT3506(B)	Introduction to Stochastic Processes Or Actuarial Statistics	3
	STAT3507	Statistics Practical- I	2
	STAT3508	Statistics Practical- II	2
	STAT3509	Statistics Practical- III	2
	CC	Certificate Course	2
VI	STAT3601	Introduction to Regression Analysis	3
	STAT3602	Statistical Inference- II	3
	STAT3603	Statistical Quality Control and Reliability	3
	STAT3604	Operations Research	3
	STAT3605	Statistical Computing Using R- Software	3
	STAT3606(A) STAT3606(B)	Official Statistics Or Biostatistics	3
	STAT3607	Statistics Practical- IV	2
	STAT3608	Statistics Practical- V	2
	STAT3609	Project	2

Note:

Paper Code	Title of Paper	Practical Based on Paper
STAT3507	Statistics Practical- I	Design of Experiments
STAT3508	Statistics Practical- II	Distribution Theory, Statistical Inference- I and Sampling Methods
STAT3509	Statistics Practical- III	C- Programming
STAT3607	Statistics Practical- IV	Introduction to Regression Analysis and Operations Research
STAT3608	Statistics Practical- V	Statistical Inference- II and Statistical Quality Control and Reliability
STAT3609	Project	Project

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3501
Paper : I Title of Paper : Distribution Theory
Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

1. To learn how to apply continuous probability distribution to various business problems.
2. To provide a through theoretical grounding in different type of distributions.
3. To train students with essential tools for statistical analysis understanding through real-world of statistical applications.
4. To present the general theory of statistical distributions as well as the standard distributions found in statistical practice.
5. To learn general strategies for problems about order statistics and applications of order statistics.

B) Learning Outcome:

Students should be able to:

1. Develop problem solving techniques needed to calculate probabilities.
2. Understand the most common continuous probability distributions and their real-life applications.
3. Understanding of distribution helps to understand the nature of data and to perform appropriate analysis.
4. The paper shall expose the students to different aspects of distribution theory. On studying this paper students can get to learn the theory underlying the construction of these distributions.
5. Thoroughly understanding the procedures of probability distributions students can apply these distributions to model random events.
6. On studying the theory of order statistics students can learn how to model product failure, droughts, floods and other extreme occurrences.

TOPICS/CONTENTS:

Unit - 1. Beta Distribution **(9 L)**

1.1 Beta distribution of first kind: p.d.f

$$f(x) = \frac{1}{B(m,n)}\, x^{m-1}(1-x)^{n-1}, \qquad 0 \le x \le 1, \qquad m,n > 0$$

$$= 0, \qquad elsewhere$$

Notation: $X \sim \beta_1(m,n)$, Nature of probability curve, Derivation of mean, variance, r[th] raw moment, harmonic mean, mode, symmetry of the distribution.

1.2 Relation with U (0, 1), probability distributions of $\frac{1}{X}, X+Y, X-Y, XY, \frac{X}{Y}$, where X and Y are iid $\beta_1(1,1)$

1.3 Beta distribution of second kind: p.d.f. $f(x) = \frac{1}{B(m,n)} \frac{x^{m-1}}{(1-x)^{m+n}} \quad ; x \ge 0,\ m,n > 0$

$$= 0 \qquad ; elsewhere$$

Notation: $X \sim \beta_2(m,n)$, Nature of probability curve, Derivation of mean, variance, r[th] raw moment, harmonic mean, mode, symmetry of the distribution.

1.4 Derivation of interrelation between $\beta_1(m,n)$ and $\beta_2(m,n)$

1.5 Derivation of distribution of $\frac{X}{Y}, \frac{X}{X+Y}$, where X and Y are independent gamma variates.

1.6 Statement of relation between distribution function of $\beta_1(m,n)$ and binomial distribution.

1.7 Illustrative examples.

Unit – 2 Weibull Distribution **(4 L)**

2.1 p.d.f . $f(x) = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} exp\left\{-\left(\frac{x}{\alpha}\right)^{\beta}\right\} \ ; x \ge 0, \alpha, \beta > 0$

$$= 0 \qquad ; elsewhere$$

Notation X ~ W (α, β)

2.2 Probability curve, location parameter, shape parameter, scale parameter. Derivation of distribution function, quartiles, mean and variance, coefficient of variation, relationship with gamma and exponential distribution.

2.3 Illustrative examples.

Unit – 3 Pareto Distribution **(4 L)**

3.1 p.d.f. with parameters (α, β) $f(x) = \frac{\alpha\beta^{\alpha}}{x^{\alpha+1}} \quad ; x \ge \beta \text{ and } \alpha, \beta > 0,$

$$= 0 \qquad ; elsewhere$$

Notation X ~ Pareto (α, β)

3.2 Probability curve, shape parameter, scale parameter.

3.3 Derivation of distribution function, quartiles, mean, variance, mode, skewness.

3.4 Relationship with exponential distribution, applications.

3.5 Illustrative examples.

Unit – 4 Order Statistics **(5 L)**

4.1 Order Statistics for a random sample of size n from a continuous distribution, definition, derivation of distribution function and density function of the i^{th} order statistics $X_{(i)}$, particular cases for $X_{(1)}$ and $X_{(n)}$.

4.2 Distribution of $X_{(i)}$ for a random sample from uniform and exponential distribution.

4.3 Joint distribution of r^{th} and s^{th} order statistic $(X_{(r)}, X_{(s)})$ for a random sample from uniform and exponential distribution.

4.3 Distribution of sample median for a random sample from uniform distribution.

4.4 Distribution of sample range

4.5 Illustrative examples.

Unit – 5 Cauchy Distribution **(5 L)**

5.1 p.d.f. $f(x) = \frac{\lambda}{\pi} \frac{1}{\lambda^2+(x-\mu)^2}; \ -\infty < x < \infty, -\infty < \mu < \infty, \lambda > 0.$

$= 0 \quad ; elsewhere$

Notation: X ~ C (μ, λ)

5.2 Nature of the probability curve, comparison with tails of normal distribution.

5.3 Derivation of distribution function, quartiles, non – existence of moments, statement of distribution of ɑX + b, derivation of distribution of i) $\frac{1}{x}$ ii) X^2 where X~ C (0,1), problems based on these results.

5.4 Statement of additive property for two independent Cauchy variates, statement of distribution of the sample mean, comment on limiting distribution of X.

5.5 Statement of relationship with uniform, Student's t and normal distributions.

5.6 Illustrative examples.

Unit – 6 Laplace (Double Exponential) Distribution **(5 L)**

6.1 p.d.f. $f(x) = \frac{\lambda}{2} exp(-\lambda|x-\mu|) \ ; \ -\infty < x < \infty, -\infty < \mu < \infty, \lambda > 0.$

$= 0 \quad ; elsewhere$

Notation: X~ L (μ , λ)

6.2 Nature of the probability curve.

6.3 Derivation of distribution function, quartiles.

6.4 MGF, CGF, Moments and cumulants, skewness and kurtosis.

6.5 Derivation of Laplace distribution as the distribution of the difference of two i.i.d. exponential random variables with mean $\frac{1}{\lambda}$.

6.6 Illustrative examples.

Unit –7. **Lognormal Distribution** **(7 L)**

7.1 p.d.f. $f(x) = \frac{1}{(x-a)\sigma\sqrt{2\pi}} exp\left\{\frac{-1}{2\sigma}[log_e(x-a)-\mu]^2\right\}$ $; x > a, -\infty < \mu < \infty, \sigma > 0,$

$= 0$ $; elsewhere$

Notation: X~ LN (a, μ, σ^2)

7.2 Derivation of relation with N (μ, σ^2) distribution

7.3 Nature of the probability curve.

7.4 Derivation of moments (r-th moment of X-a), mean, variance, quartile, mode, Karl Pearson's and Bowley's coefficient of skewness and kurtosis, derivation of quartiles and mode.

7.5 Distribution of $(\prod x_i)$, when X_i's independent lognormal random variables.

7.6 Illustrative examples.

Unit – 8. Bivariate Normal Distribution. **(9L)**

8.1 p.d.f of a bivariate normal distribution.

$$f(x) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\, exp\left\{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_1}{\sigma_1}\right)^2 + \left(\frac{y-\mu_2}{\sigma_2}\right)^2 - 2\rho\left(\frac{x-\mu_1}{\sigma_1}\right)\left(\frac{y-\mu_2}{\sigma_2}\right)\right]\right\};$$

$$; -\infty < x, y < \infty,$$
$$-\infty < \mu_1, \mu_2 < \infty$$
$$\sigma_1, \sigma_2 > 0, -1 < \rho < 1$$

Notation (X, Y) ~BN $(\mu_1, \mu_2, \sigma_1, \sigma_2, \rho)$

8.2 Nature of surface of p.d.f., marginal and conditional distributions, identification of parameters, regression of Y on X, independence and uncorrelatedness, Derivation of MGF and moments. Statement of distribution of aX+ bY+ c and distribution of $\frac{X}{Y}$.

8.3 Illustrative examples.

Books Recommended

1. Arora Sanjay and Bansi Lal (1989). Mathematical Statistics (1st Edition), Satya Prakashan 16/17698, New Delhi.
2. Cramer H.: (1962) Mathematical Method of Statistics, Asia Publishing House, Mumbai
3. Gupta S. C. and Kapoor V. K.: (2006). Fundamental Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi.

4. Hogg, R.V. and Craig A. T. (1970). Introduction Mathematical Statistics (IIIrd Edition), Macmillan Publishing Company. Inc. New York
5. Lindgren B.W.: (1976) Statistical Theory (IIIrd Edition) Collier Macmillan international Edition, Macmillan Publishing Co. Inc. New York.
6. Mood. A.M., Graybill, F. Bose, D. C.: (1974) Introduction to theory of Statistics. (IIIrd Edition) Mc- Graw Hill Series.
7. Mukhopdhyay, P (1996). Mathematical Statistics, New Central Book Agency.
8. Rohatgi, V. K. (1975) An Introduction to probability Theory and Mathematical Statistics, Wiley Eastern Ltd. New Delhi
9. Feller, W.: An introduction of Probability Theory and its applications, Wiley Eastern Ltd. Mumbai.
10. Jhonson and Kotz: Continuous Univariate Distributions I and II: Discrete distributions.
11. Bhat B. R.: Modern Probability Theory, New Age International.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT- 3502
Paper : II Title of Paper : Statistical Inference- I
Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

The main objective of this course is to get knowledge about

1. The concept of estimation of parameters.
2. Notion of parameter and estimator.
3. Applying various methods of estimation.
4. Important inferential aspects such as point estimation and interval estimation.
5. Properties of a good estimator.
6. Efficient estimator through relative efficiency, MVUE, UMVUE and MVBUE.

B) Learning Outcome:

After completing this course, students will possess skills concerning:

1. Estimation, Parameter, statistic, standard error, sampling distribution of a statistic,
2. Characteristics of a good estimator
3. Different methods of estimation

TOPICS/CONTENTS:

Unit 1: Point Estimation (4 L)

1.1 Notion of a parameter, parameter space, sample space as a set of all possible values of $(X_1, X_2, \ldots, X_n)$,general problem of estimating an unknown parameter by point and interval estimation.

1.2 Point Estimation: Definition of an estimator, distinction between estimator and estimate, illustrative examples.

1.3 Mean Square Error (MSE) of an estimator.

Unit 2: Methods of Estimation (10 L)

2.1 Method of moments: Derivation of moment estimators for standard distributions. Illustrations of situations where M.L.E. and moment estimators are distinct and their comparison using mean square error. Examples and problems.

2.2 Method of maximum likelihood:

2.2.1: Definition of likelihood as a function of unknown parameter, for a

random sample from i) discrete distribution ii) continuous distribution. Examples and problems.

2.2.2: Derivation of maximum likelihood estimator (M.L.E.) for parameters of only standard distributions (case of two unknown parameters only for normal distribution).

2.2.3: M.L.E. of θ in uniform distribution over i) $(0, \theta)$ ii) $(-\theta, \theta)$ iii) $(m\theta, n\theta)$ $(m < n)$

2.2.4: M.L.E. of θ in $f(x ; \theta) = \text{Exp}\{-(x- \theta)\}$, $x > \theta$.

2.2.5: M.L.E. of location parameter in Laplace distribution.

2.2.6: Invariance property of M.L.E.

Unit 3: Properties of Estimators

3.1 Unbiasedness (4 L)

Definition of an unbiased estimator, biased estimator, positive and negative bias, illustrations and examples. Proofs of the following results regarding unbiased estimators:

(a) Two distinct unbiased estimators of θ give rise to infinitely many estimators.

(b) If T is an unbiased estimator of θ, then ϕ (T) is unbiased estimator of ϕ (θ) provided ϕ (.) is a linear function.

3.2 Efficiency (4 L)

Relative efficiency of unbiased estimator T_1 with respect to another unbiased estimator T_2, use of mean square error to define relative efficiency of biased estimators, Notion of the Best Linear Unbiased Estimator and Uniformly Minimum Variance Unbiased Estimator (UMVUE), uniqueness of UMVUE whenever it exists, Examples and problems.

3.3 Sufficiency (7 L)

Concept and definition of sufficiency, statement of the Fisher-Neyman factorization theorem with proof for discrete probability distribution. Pitmann – Koopman form and sufficient statistic; Exponential family of probability distributions and sufficient statistic. Examples and problems.

Proofs of the following properties of sufficient statistics:

(a) If T is sufficient for θ, then ø (T) is also sufficient for θ provided ø is a one to one and onto function.

(b) If T is sufficient for θ then T is also sufficient for ø (θ).

(c) M.L.E. is a function of sufficient statistic.

3.4 Asymptotic Behavior of an Estimator (6 L)

Chebychev's inequality for discrete and continuous distributions. Consistency: Definition. Proof of the following theorems:

(a) An estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity.

(b) If T is consistent estimator of θ and ø (.) is a continuous function, then ø (T) is a consistent estimator of ø (θ)

Examples and problems.

Unit 4: Cramer- Rao Inequality (7 L)

4.1 Fisher information function: Amount of information contained in statistic T = $T(X_1, X_2, \ldots, X_n)$. Statement regarding information in sample and in a sufficient statistic T.

4.2 Cramer- Rao Inequality

4.2.1: Statement and proof of Cramer - Rao inequality, Cramer – Rao Lower Bound (CRLB), definition of minimum variance bound unbiased estimator (MVBUE) of ø (θ). Examples and problems.

4.2.2: Proofs of following results:

(a) If MVBUE exists for θ then MVBUE exists for ø (θ) where ø (.) is a linear function.

(b) If T is MVBUE for θ then T is sufficient for θ.

4.2.3: Comparison of variance with CRLB, relative efficiency of T_1 w. r. t. T_2 for (i) unbiased (ii) biased estimators. Efficiency of unbiased estimator T w. r. t. CRLB.

Unit 5: Interval Estimation (6 L)

5.1 Notion of interval estimation, definition of confidence interval (C.I), length of C.I., Confidence bounds, confidence coefficient. Definition of pivotal quantity and its use in obtaining confidence intervals.

5.2 Interval estimation for the following cases:

i) Mean (μ) of normal distribution (when σ^2 known and σ^2 unknown).

ii) Variance (σ^2) of normal distribution (when μ known and μ unknown).

iii) Median, quartiles using order statistics.

Books Recommended

1. Kale B. K. and Murlidharan K. (2015) Introduction to Parametric Inference, Narosa Publication House, New Delhi.
2. Rohatagi, V. K. (1975) An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
3. Lehman E. L. (1988) Theory of point estimation (John Wiley)
4. Dudeweitz, E. J. and Mishra, S. N. (1988) Modern Mathematical Statistics, John Wiley and Sons, Inc.
5. Hoel, P. G. Port, S. and Stone, C. (1972) Introduction to Statistical Theory, Houghton Mifflin Company (International) Dolphin Edition.
6. Hogg, R. V. and Craig, A. T. (1978) Introduction to Mathematical Statistics (fourth edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc., New York
7. Kendall, M. and Stuart, A. (1943) The advanced Theory of Statistics, Vol- 1, Charles and Company Ltd., London
8. Lindgren, B. W. (1976) Statistical Theory (third edition) Collier Macmillan International Edition, Macmillan Publishing Co., Inc. New York
9. Mood, A. M., Graybill, F. and Bose, D. C. (1974). Introduction to the theory of Statistics (third edition) International Student Edition, McGraw Hill.
10. Ramchandran, K. M. and Tsokos C. P. (2009). Mathematical Statistics with Applications, Academic Press.
11. Casella G. and Berger R. L. (2001) Statistical Inference, 2nd edition, Duxbury press.
12. Mukhopadhyay, N. (2020) Probability and Statistical inference. CRC Press.
13. Dixit, U. J. (2016) Examples in Parametric Inference with R. Singapore: Springer.
14. Fergusson T. S. (1996) Mathematical Statistics.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3503
Paper : III Title of Paper : Sampling Methods
Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

1. Describe the situations where and how to use probability sampling methods
2. Estimating population parameters using sampling distribution of estimator and obtaining estimators of standard error in estimation under various sampling procedures.
3. Determining adequate sample size for various sampling procedures.
4. Describe the concept of sampling error and non-sampling error.
5. Explain when non-probability sampling methods may be preferred.

B) Learning Outcomes:

1. Identify and recognize the appropriate sample survey design for related problems.
2. Understand the importance of sampling and how results from samples can be used to provide estimates of population characteristics such as the population mean, the population standard deviation and / or the population proportion.
3. Estimates the convenient sample size for Simple random sampling and stratified random sampling.
4. Have an appreciation of the practical issues arising in sampling studies.

TOPICS/CONTENTS:

Unit-1. Sampling (8 L)

1.1 Concept of distinguishable elementary units, sampling units, sampling frame, random sample, requisites of a good sample. Simple random sampling from finite population of size (N) (i) with replacement (SRSWR) ii) without replacement (SRSWOR) definitions, population mean and population total as parameters, inclusion probabilities.

1.2 (a) Sample mean $\bar{y}$ as an estimator of population mean, derivation of expectation and standard error of $\bar{y}$, confidence interval for population mean, population total standard error.

(b) $N\bar{y}$ as an estimator of population total, derivation of expectation and standard error of $N\bar{y}$ (c) Estimator of above standard errors, both in case of SRSWR and SRSWOR.

1.3 Sampling for proportion as an application of a simple random sampling with X_i as zero or one.

(a) sample proportion as an estimator of population proportion of units possessing a certain attribute, derivation of expectation and standard error of (p).

(b) N_p as an estimator of total number of units in the population possessing a certain attribute, derivation of expectation and standard error of N_p

(c) Estimator of above standard error both in case of SRSWR and SRSWOR.

Unit-2. Determination of Sample Size (in case of SRS) (4 L)

2.1 Determination of the sample size for the given:

(a) Margin of error and confidence coefficient.

(b) Coefficient of variation of the estimator and confidence coefficient.

Unit-3. Stratified Random Sampling (12 L)

3.1 Stratification, basis of stratification, real life situation where stratification can be used.

3.2 Stratified random sampling as a sample drawn from individual strata using SRSWOR in each stratum.

3.3 (a) $\overline{y_{st}} = \frac{\sum N_i \bar{y}_i}{N}$ as an estimator of population mean ($\bar{Y}$), Derivation of expectation and standard error of $\overline{y_{st}}$.

(b) N $\overline{y_{st}}$ as an estimator of population total, derivation of expectation and standard error of $N\overline{y_{st}}$.

(c) Estimator of above standard errors.

3.4 Problem of allocation, proportional allocation, Neyman's allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used.

3.5 Gain in precision due to stratification, comparison amongst SRSWOR, stratification with proportional allocation and stratification with Neyman's allocation.

3.6 Cost and variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation,

Neyman's allocation as a particular case of optimum allocation in cost and variance analysis.

Unit-4. Ratio and Regression Methods of Estimation for SRSWOR (Sampling Methods using Auxiliary variables) (6 L)

4.1 Rationale behind using auxiliary variates in estimation.

4.2 Situations where (a) ratio method is appropriate, (b) regression method is appropriate.

4.3 Ratio and regression estimators of the population mean and population total.

4.4 Comments regarding bias, statement of standard errors of ratio and regression estimators relative efficiency of these estimators, with respect to SRSWOR. (Derivations are not expected).

Unit-5. Systematic Sampling (Linear Systematic Sampling) (6 L)

5.1 Real life situations where systematic sampling is appropriate. Techniques of drawing a sample using systematic sampling.

5.2 Estimation of the population mean and population total, standard error of these estimators.

5.3 Comparison of systematic sampling with SRSWOR.

5.4 Comparison of systematic sampling with SRSWOR and stratified sampling in the presence of linear trend.

Unit-6. Role of Sample Surveys in Research Methodology (8 L)

6.1 Objectives of a sample survey.

6.2 Designing a questionnaire, characteristics of a good questionnaire (Questions with codes & scores are to be discussed). Reliability and validity testing by using

(a) Test – Retest method

(b) Internal Consistency: (i) Kuder Rechardson Coefficient (KR-20)

(ii) Cronbach's Coefficient Alpha

6.3 Planning, execution and analysis of a sample survey, practical problems at each of these stages.

6.4 Sampling and non-sampling errors with illustrations.

6.5 Study of some surveys illustrating the above ideas, rounds conducted by National Sample Surveys organization.

Unit-7. Non-probability sampling techniques (4 L)

7.1 Quota sampling, Convenience sampling, Purposive sampling and snowball sampling.

Books Recommended

1) Cochran, W. G. (1977) Sampling Techniques, third Edition Wiley Eastern Ltd., New Delhi.
2) Malhotra N. (2008) Marketing Research and Applied Orientation (third edition), Prentice Hall of India.
3) Mukhopadhyay P (2008) Sampling theory and methods of survey sampling. Prentice-Hall of India, New Delhi.
4) Murthy, M. N. (1967) Sampling methods, Indian Statistical Institute, Kolkata.
5) Singh, D. and Chaudhary, F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
6) Sukhatme, P. V., Sukhatme, B. V. (1984) Sampling theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3504
Paper : IV Title of Paper : Design of Experiments
Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

1. The main objective of this course is to learn and understand various designs of experiments.
2. Students should be able to identify the design, carryout various experiments and analyze the data.
3. Students should be able to apply appropriate design in real life situation.

B) Learning Outcomes:

1. Students will be able to understand basic principles and various terms of Design of Experiments.
2. Students will be able to apply Factorial design, confounding in real life problems.
3. Students should be able to analyze the data of various experimental design.

TOPICS/CONTENTS:

Unit-1 Introduction (4 L)

1.1 Concept of Design of Experiment (DOE), Introduction to basic terms of Design of Experiments, Experimental unit, treatments, layout of an experiment, factor, level, run of experiment, control experiment, test experiment.

1.2 Basic principles of Design of Experiments, Randomization, Replication and Local control. 1.3 Uniformity trials.

1.4 Choice of size and shape of a plot.

1.5 The empirical formula for the variance per unit area of plots.

Unit-2 Standard Designs of Experiments (15 L)

2.1 Completely Randomized Design (CRD): Application of the principles of design of experiment in CRD, Layout of CRD, Model: $X_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ $i = 1, 2, \ldots, t$; $j = 1, 2, \ldots, n_i$ assumptions and interpretations. Testing normality graphically. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of

(ANOVA) table, testing equality of treatment effects, Hypothesis to be tested $H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_t = 0$. Comparison of treatment means using box plot techniques. Statement of Cochran's theorem. F test for testing H_0 with justification (independence of chi- square is to be assumed), test for equality of two specified treatment effects using critical difference (C.D). Merits and demerits of CRD.

2.2 Randomized Block Design (RBD): Application of the principles of design of experiments in RBD, layout of RBD, Model: $X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ i = 1, 2, …, t; j = 1, 2, …, b, Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, Hypotheses to be tested $H_{01} : \alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_t = 0$; $H_{02} : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_b = 0$. F test for testing H_{01} and H_{02} with justification (independence of chi-squares is to be assumed), test for equality of two specified treatment effects using critical difference (CD). Merits and demerits of RBD.

2.3 Latin Square Design (LSD): Application of the principles of design of experiments in LSD, layout of LSD, Model: $X_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$ i = 1, 2, ···, m; j = 1, 2, ···, m; k = 1, 2, ···, m. Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, hypotheses to be tested. $H_{01} : \alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_m = 0$; $H_{02} : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_m = 0$; $H_{03} : \gamma_1 = \gamma_2 = \cdots = \gamma_m = 0$ and their interpretation. Justification of F test for H_{01}, H_{02} and H_{03} (independence of chi- square is to be assumed). Preparation of ANOVA table and F test for H_{01}, H_{02} and H_{03} testing for equality of two specified treatment effects, comparison of treatment effects using critical difference, linear treatment contrast and testing its significance. Merits and demerits of LSD.

2.4 Linear treatment contrasts, orthogonal contrasts. Scheffe's method for comparing contrasts, Tuckey's procedure for comparing pairs of treatment means (applicable to C.R.D., R.B.D. and L.S.D.)

2.5 Identification of real-life situations where the above designs are useful.

Unit-3 Analysis of non- normal data using **(5 L)**

3.1 Square root transformation for counts.

3.2 Sin^{-1} (.) transformation for proportions.

3.3 Kruskal Wallis test.

Unit-4 Efficiency of a Design **(5 L)**

4.1 Concept and definition of efficiency of a design.

4.2 Efficiency of RBD over CRD.

4.3 Efficiency LSD over CRD.

4.4 Efficiency LSD over RBD taking

i) Row as a Block.

ii) Column as a Block.

4.5 Simple numerical problems.

Unit-5 Analysis of Covariance (ANOCOVA) **(7 L)**

5.1 Situations where analysis of covariance is applicable.

5.2 Model for ANOCOVA in CRD and RBD with One Concomitant Variable. Estimation of parameters (derivations are not expected)

5.3 Preparation of analysis of variance – covariance table, test for $\beta = 0$, test for equality of treatment effects (computational technique only).

Unit-6 Factorial Experiments **(12 L)**

6.1 General description of $m \times n$ factorial experiment, 2^2 and 2^3 factorial experiments arranged in RBD.

6.2 Definitions of main effects and interaction effects in 2^2 and 2^3 factorial experiments.

6.3 Yate's procedure, preparation of ANOVA table, test for main effects and interaction effects.

6.4 General idea of confounding in factorial experiments.

6.5 Construction of layouts in total confounding and partial confounding in 2^2 and 2^3 factorial experiments.

6.6 Total confounding (confounding only one interaction) ANOVA table, testing main effects and interaction effects.

6.7 Partial confounding (confounding only one interaction per replicate); ANOVA table, testing main effects and interaction effects.

6.8 Construction of layouts in total confounding and partial confounding for 2^2, 2^3 factorial experiments.

Books Recommended

1. Cochran W. G. and Cox, C. M. (1968) Experimental Design, John Wiley and Sons, Inc., New York.
2. Dass, M. N. and Giri, N. C. (1986) Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi
3. Federer W. T. (1967) Experimental Design: Oxford and IBH Publishing Co., New Delhi
4. Goon, A.M., Gupta, M. K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pvt. Ltd. Kolkatta
5. Gupta S. C. and Kapoor V. K. (2006). Fundamentals of Applied Statistics, S. Chand Sons, New Delhi
6. Johnson, R. A., Miller, I. and Freund, J. (2010). Probability and Statistics for engineers, Prentice Hall, India.
7. Kempthorne, O. (1952). Design of Experiments, Wiley Eastern Ltd., New Delhi.
8. Montgomery, D. C. (2001). Design and Analysis of Experiments, John Wiley and sons Inc., New Delhi.
9. Snedecor, G. W. and Cochran, W. G. (1994). Statistical Methods, 8th edition, Affiliated East – West Press, New Delhi
10. Wu, C. F. J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc., Hoboken, New Jersey.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3505

Paper : V Title of Paper : C- Programming

Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

Students successfully completing this course will be able:

1. The course realizes and design algorithm for problem solving.
2. The objective of the course is to develop problem solving abilities using computers.
3. The student will develop skills for writing programs using C.

B) Learning Outcome:

1. Student will be solved to problems using programming capability.
2. Student will be exploring their algorithmic approaches to problem solving.
3. Student will be developed modular programs using control structures, pointers, arrays, strings and functions.

TOPIC CONTENT

Unit 1: C Fundamental (12 L)

1.1 History of 'C' language, Application areas, Structure of a 'C' program, 'C' Program development life cycle, Function as building blocks,

1.2 'C' tokens: Character set, Keywords, Identifiers, Variables, Constants (character, integer, float, string, escape sequences, enumeration constant),

1.3 Data Types: Numeric and character data types, Numeric and character constants, string constants, symbolic constants.

1.4 Operators, Types of operators: arithmetic, relational, logical, assignment, bitwise, conditional. Expressions, types of operators, Operator precedence and Order of evaluation.

1.5 Character input and output, String input and output, Formatted input and output.

Unit 2: Control Structure (10 L)

Decision making structures: - if, if-else, switch and conditional operator, Loop control structures: - while, do while, for, use of break and continue, Nested structures, Unconditional branching (goto statement)

Unit 3: Array **(10 L)**

Concept, declaration, definition, initialization of array, problem using arrays, passing to function.

List of programs using arrays.

3.1 To find mean, median, variance and coefficient of variation of frequency distribution.

3.2 To find correlation coefficient and least square regression line of Y on X for a given bivariate data.

3.3 To arrange the given data in increasing/decreasing order of magnitude.

3.4 To obtain median of given n observations.

3.5 To obtain addition of two matrices, multiplication of two matrices.

Unit 4: String **(4 L)**

String Literals, string variables, declaration, definition, initialization, Syntax and string operations, use of predefined string functions, string functions like strcpy(), strcat(), strlen(), strcmp(), strrev(). Array of strings.

Unit 5: Function **(8 L)**

Concept of function, Standard library functions, User defined functions: - declaration, definition, function call, parameter passing (by value), calling a function by reference and by value, return statement. Recursive functions, Scope of variables. local and global variables. List of writing functions:

1. To find factorial of integer number (both recursive and non-recursive)
2. To find the value of Xn where n is integer. (both recursive and non-recursive)
3. To find GCD of two integer numbers (both recursive and non-recursive)
4. To find maximum/minimum of n numbers. (non-recursive)

Unit 6: Pointer **(4 L)**

Introduction to Pointers. Declaration, definition, initialization, dereferencing. Pointer arithmetic. Relationship between Arrays & Pointers- Pointer to array, Array of pointers.

List of Simple Programs (short programs)

1. Converting °C temperature to °F.
2. To carry out arithmetic calculations.
3. To check whether given number is odd or even.
4. To check whether given number m is divisible by n or not.

5. To find maximum of 2 numbers or 3 numbers.
6. To find area of triangle and circle.
7. To find roots of quadratic equation.
8. To check whether integer is prime or not.
9. To find mean, Geometric mean and Harmonic Mean of n numbers.
10. To prepare multiplication table.
11. To find sum of digits of a number.
12. To solve simultaneous linear equations. (two equations in two variables)
13. To evaluate simple and compound interest
14. To evaluate exp(x), sin (x), log (x) etc. using Taylor‟s series expansion.
15. To convert decimal number to equivalent binary number.
16. To generate Fibonacci series like 0, 1, 1,2,3,5…
17. To test palindrome string using string function.
18. To sort a string using string function.
19. To search string using string function.
20. To combine given two strings using string function.

List of programs (long programs)

21. Program in C to prepare a frequency distribution with given class interval from raw data.
22. Program in C to find mean, variance, standard deviation and quartiles for given n observations and frequency distribution.
23. Program in C to fit a Binomial distribution to given data.

Books Recommended:

1. How to Solve it by Computer, R.G. Dromey, Pearson Education.
2. Problem Solving and Programming Concept, Maureen Sprankle,7th Edition, Pearson Publication.
3. C: the Complete Reference, Schildt Herbert, 4 th edition, McGraw Hill
4. A Structured Programming Approach Using C, Behrouz A. Forouzan, Richard F. Gilberg, Cengage Learning India
5. The ‘C’ programming language, Brian Kernighan, Dennis Ritchie, PHI
6. Programming in C, A Practical Approach, Ajay Mittal, Pearson
7. Programming with C, B. Gottfried, 3rd edition, Schaum’s outline Series, Tata McGraw Hill. 8. Programming in ANSI C, E. Balagurusamy, 7th Edition, McGraw Hil.
8. Let us C, Kanitkar, Y (2008) BFB publishers, New Delhi.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3506 (A)
Paper : VI (A) Title of Paper : Introduction To Stochastic Processes
Credit : 3 credits No. of lectures : 48

A) Learning objectives:

1. To provide the students with a fundamental understanding of the stochastic processes and Markov chains.
2. Students should be able to construct transition probability matrix (tpm), find the n-step transition probabilities and classify its states.

B) Learning outcomes:

1. Students will be able to formulate tpm, n-step transition probabilities
2. Students will be able to classify of states.
3. Students will become familiar with Poisson process.

TOPICS/CONTENTS:

UNIT 1: Introduction (18 L)

Definition of a Stochastic process, state space ,parameter space, types of stochastic processes, Markov Chains (MC) $\{X_n, n \geq 0\}$, finite MC, time homogeneous MC one step transition probabilities, and transition probability matrix (t.p.m.), stochastic matrix, Chapman Kolmogorov equation, n-step transition probability matrix, initial distribution, joint distribution function of $\{X_0, X_1, \ldots, X_n\}$, partial sum of independent and identically distributed random variables as Markov Chain, illustrations such as random walk, Gambler's ruin problem, Ehrenfest chain.

UNIT 2: Classification of States (12 L)

Classification of states: Communicating states, first return probability, probability of ever return Classification of states, as persistent and transient states. Decomposition of state space, closed set of states, irreducible set of states, irreducible MC, periodicity of M.C. aperiodic M.C. ergodic M. C.

UNIT 3: Stationary distribution (6 L)

Stationary distribution for an irreducible ergodic finite Long run behaviour of a MC

UNIT 4: Poisson Process (12L)

Poisson process: Postulates and properties of Poisson process, probability distribution of N(t), the number of occurrences of the event in (0, t], Poisson process and probability

distribution of inter-arrival time, mean, variance and covariance functions. Definition of compound Poisson

Books Recommended:

1. Medhi J. (1982) Stochastic processes (Wiley Eastern)
2. Ross, S. (1996) Stochastic processes (John Wiley)
3. Ross, S. (2000) Introduction to probability models, 7th edition (Academic Press)
4. Hoel , P.G.,Port, S.C. ,Stone, C.J. (1972) : Introduction to stochastic processes
5. Bhat, B.R. (2000) stochastic models: Analysis and applications (New Age International)
6. Adke, S.R., Manjunath, S.M. (1984) An introduction to finite Markov processes (Wiley Eastern)
7. Taylor, H N and Karlin, S. (1984) An introduction to stochastic modeling(Academic Press)

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3506 (B)
Paper : VI (B) Title of Paper : Actuarial Statistics
Credit : 3 credits No. of lectures : 48

A) Learning objectives:

Students successfully completing this course will be able:

1. The main objective of this course is to learn and understand various concepts involved in Actuarial Statistics.
2. Students should be able to describe, explain and apply the fundamental theories of actuarial statistics as they apply in life insurance, endowment insurance, n-year term life insurance.
3. Students should be able to apply appropriate modeling techniques for lifetime random variables involved in the field of Insurance.

B) Learning outcomes:

1. Students should be able to identify and analyze consequences of events involving risk and uncertainty.
2. Students should be able to calculate survival function, curtate future lifetime, force of mortality.
3. Students should be able to calculate various payments from life tables using principle of equivalence, net premiums.

TOPICS/CONTENTS:

Unit- 1 Insurance Business (3 L)

1.1 Insurance companies as business organizations.

1.2 Role of insurance business in Economy.

1.3 Concept of risk, types of risk, characteristics of insurable risk.

1.4 Working of insurance business, introduction of terms such as premium, policy, policyholder and benefit.

1.5 Role of Statistics in insurance.

1.6 Insurance business in India.

Unit- 2 Feasibility of Insurance Business (4 L)

2.1 Measurement of adverse financial impact, expected value principle.

2.2 Concept of utility function

2.3 Feasibility of insurance business.

2.4 Illustrative examples.

Unit- 3 Survival Distribution and Life Tables (12 L)

3.1 Time- until death random variable, its d.f. and survival function in actuarial notation.

3.2 Force of mortality.

3.3 Interrelations among d.f., survival function, force of mortality and p.d.f.

3.4 Curtate future life random variable, its p.m.f. and survival function in actuarial notation.

3.5 Construction of life table using random survivorship approach.

Unit- 4 Models for Life Insurance (11 L)

4.1 Theory of compound interest, effective rate of interest, discount factor.

4.2 Insurance payable at the end of the year of death, present value random variable, actuarial present value.

4.3 Derivation of actuarial present value for n-year term life insurance, whole life insurance and endowment insurance.

Unit- 5 Annuities (10 L)

5.1 Annuities – certain, annuity due, annuity immediate.

5.2 Discrete life annuities: n-year temporary life annuity due and a whole life annuity due, present value random variables of the payment, and their actuarial present values.

Unit- 6 Benefit Premiums (8 L)

6.1 Concept of a loss random variable.

6.2 Equivalence principle

6.3 Computation of fully discrete premium for n-year term life insurance, whole life insurance and endowment insurance.

6.4 Variance of loss random variable

Books Recommended

1. Bowers N. L. Jr., H. S. Gerber, J. C. Hickan, D. A. Jones, C. J. Nesbitt, (1997) Actuarial Mathematics, Society of Actuaries, U. S.
2. Deshmukh, S. R. (2009) Actuarial Statistics, Universities Press, Hyderabad, India.
3. Actuarial Mathematics, Society of Actuaries, ltasca, lllinois, U.S.A. 2nd Ed. (1997)
4. Spurgeon E.T. (1972) Life Contingencies, Cambridge University Press. Neill, A. Life Contingencies, Heinemann.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3507
Paper : VII Title of Paper : Statistics Practical- I
Credit : 2 credits

A) Learning objectives:

1. The main objective of this course is to learn and understand the various analysis techniques in designs of experiments such as ANOVA, ANOCOVA, etc.
2. Students should be able to identify the design, carryout various experiments and analyze the data.

B) Learning outcomes:

1. Students will be able to understand basic principles and various terms of Design of Experiments.
2. Students will be able to apply Factorial design, confounding in real life problems.
3. Students should be able to analyze the data of various experimental design.

Sr. No.	Title of Experiments
1.	Analysis of CRD (equal and unequal replications, pairwise comparison of treatments, using critical difference (C.D). Check normality using normal probability plot.
2.	Analysis of RBD (pairwise comparison of treatments using i) C.D ii) Tukey test iii) Scheff's test. Efficiency of RBD w.r.t. CRD
3.	Analysis of RBD. Efficiency of RBD w.r.t. CRD
4.	Analysis of LSD and Calculation of Efficiency (pairwise comparison of treatments using C.D. and box plot, efficiency of LSD w.r.t. i) CRD ii) RBD)
5.	Kruskal-Wallies H test
6.	Analysis of Covariance in CRD
7.	Analysis of Covariance in RBD
8.	Analysis of 2^2 and 2^3 factorial experiments in RBD.
9.	Analysis of 2^3 factorial experiments in RBD (partial confounding)
10.	Analysis of 2^3 factorial experiments in RBD (total confounding)

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3508
Paper : VIII Title of Paper : Statistics Practical- II
Credit : 2 credits

A) Learning Objectives:

1. Students should be able to understand properties and applications of standard distribution.
2. The main objective of this course is to get knowledge about important inferential aspects of interval estimation.
3. Estimating population parameters using sampling distribution of estimator and obtaining estimators of standard error in estimation under various sampling procedures.
4. Determining adequate sample size for various sampling procedures.

B) Learning Outcomes:

1. Student will be able to fit the distributions.
2. Students will be able to draw model sample from distributions.
3. Students will be able to apply appropriate sample survey design for related problems.
4. Estimates the convenient sample size for Simple random sampling and stratified random sampling.

Sr. No.	Title of Experiments
1.	Model sampling from Cauchy and Laplace distributions
2.	Fitting of lognormal distribution
3.	M.L.E and moment estimator of truncated Binomial and truncated Poisson distributions (truncated at zero)
4.	Construction of confidence interval for population median and quartiles, based on order statistics.
5.	Simple random sampling (estimation of population mean, population total with standard errors), i) with replacement, ii) without replacement. Confidence interval for population mean and population total.

6.	Stratified random sampling: Proportional and Neyman allocation, comparison with SRSWOR.
7.	Stratified random sampling: cost and variance analysis.
8.	Ratio methods of estimation. Comparison with SRSWOR.
9.	Regression methods of estimation. Comparison with SRSWOR.
10.	Determination of Sample Size.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
(With Effect from Academic Year 2021-2022)

Paper Code : STAT-3509
Paper : IX Title of Paper : Statistics Practical- III
Credit : 2 credits

A) Learning objectives:

Students successfully completing this course will be able:

1. The objective of the course is to develop problem solving abilities using computers.
2. The student will develop skills for writing programs using C.

B) Learning outcomes:

1. Student will be solved to problems using programming capability.
2. Student will be exploring their algorithmic approaches to problem solving.
3. Student will be developed modular programs using control structures, pointers, arrays, strings and functions.

Sr. No.	Title of Experiments
1.	A) Converting °C temperature to °F. B) To check whether given number is odd or even. C) To find maximum of 2 numbers or 3 numbers. D) To find area of triangle and circle.
2.	A) To find roots of quadratic equation.
3.	To check whether integer is prime or not.
4.	To find mean, Geometric mean and Harmonic Mean of n numbers.
5.	A) To find mean, variance and coefficient of variation of n observations. B) Arrange the observations in ascending order of magnitude and find median of n observations.
6.	To find mean, median, variance and coefficient of variation of frequency distribution when fi and xi are given.
7.	To find correlation coefficient for a given bivariate data.
8.	To fit a line of regression of Y on X for a given bivariate data.
9.	To fit a Binomial distribution to given data.
10.	To obtain addition of two matrices, multiplication of two matrices.