

UNIVERSITY OF MUMBAI
No. UG/108 of 2010

CIRCULAR:-

A reference is invited to the Ordinances, Regulations and syllabi relating to the Bachelor of Science (B.Sc.) degree course in statistics under the revised pattern vide this Office Circular No. UG/176 of 1999 dated 24th May, 1999 and the Principals of the affiliated colleges in Arts concerned are hereby informed that the recommendation made by the Board of Studies in Statistics at its meeting held on 11th December, 2009 has been accepted by the Academic Council at its meeting held on 3rd March, 2010 vide item No. 4.28 and that in accordance therewith, the syllabus in the subject of Statistics at the T.Y.B.Sc. is revised as per Appendix and that the same has been implemented from the academic year 2010-2011.

MUMBAI-400 032
29th May, 2010

(L. R. MANE)
offg. REGISTRAR

 $\Gamma_0,$

The Principals of the affiliated Colleges in Science.

A.C/4.28/03.03.2010

No. UG/108-A of 2010

MUMBAI-400 032

28th May, 2010

Copy forwarded with Compliments for information to:-

1. The Dean, Faculty of Science,
2. The Chairman, Board of Studies in Statistics.
3. The Controller of Examinations,
4. The Co-ordinator, University Computerization Centre.

(D. N. JADHAV)

I/c. Deputy Registrar
U.G./P.G. Section.

Copy to:-

The Director, Board of College and University Development, the Deputy Registrar (Eligibility and Migration Section), the Director of Students Welfare, the Personal Assistants to the Vice-Chancellor, the Pro-Vice-Chancellor, the Registrar and the Assistant Registrar, Administrative, Ratnagiri for information.

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required to maintain the journal with reports or experience in a typed form, prepared with the help of a writer/scribe.

3/03/2010

UNIVERSITY OF MUMBAI



**REVISED SYLLABUS
AT
T.Y.B.Sc. EXAMINATION
IN THE
SUBJECT
OF
STATISTICS**

(With effect from the academic year 2010-2011)

STATISTICSPAPER IPROBABILITY THEORY AND STOCHASTIC PROCESSUnit 1 PROBABILITY:

30L

- i) Theorems on Probability of realization of : a) At least one
 b) Exactly m c) At least m of N events $A_1, A_2, A_3, \dots, A_N$.
 ii) Maxwell Boltzmann, Bose Einstein and Fermi Dirac Statistics.
 iii) Ordered samples and runs.
 iv) Matching and Guessing problems.
 Chebychev's theorem, Chebychev's Inequality.

(Ref. 1,2)

GENERATING FUNCTIONS:

Definitions of generating function and probability generating function.
 Expression for mean and variance in terms of generating functions.
 Definition of a convolution of two or more sequences. Generating function of a convolution. Generating functions of the standard discrete distributions. Relation between i) Bernoulli and Binomial distributions
 ii) Geometric and negative Binomial distributions in terms of convolutions.

(Ref. 1)

Unit 2 ORDER STATISTICS:

30L

- i) Definition of Order Statistics based on a random sample.
 ii) Derivation of : Cumulative distribution function of the r^{th} order statistic. Probability density function of the r^{th} order statistic.
 Joint Probability density function of the r^{th} and the s^{th} order statistic.
 Joint Probability density function of all the n ordered statistics.
 Probability density function of Median (in the case of odd sample sizes) and Range for Uniform and Exponential distributions.

(Ref. 2,3)

STOCHASTIC PROCESSES:

Definition of stochastic process. Postulates and difference differential equations for i) Pure birth process ii) Poisson process iii) Yule's process iv) Pure death process v) Death process with $\mu_n = \mu$ vi) Death process with $\mu_n = n\mu$ vii) Birth and death process viii) Linear growth model. Derivation of $P_n(t)$ for ii), iii), v), vi) Derivation of mean and variance for ii), iii), vi), viii)

(Ref. 1,7)

Unit 3 QUEUEING THEORY:

30L

Basic elements of the Queueing model. Roles of the Poisson and Exponential distributions. Derivation of Steady state probabilities for the birth and death process. Steady state probabilities and the various average characteristics for the following models
 i) (M/M/1) : (GD/ ∞ / ∞) ii) (M/M/1) : (GD/ N / ∞)
 iii) (M/M/c) : (GD/ ∞ / ∞) iv) (M/M/c) : (GD/ N / ∞)
 v) (M/M/c) : (GD/ N / N) $c < N$ vi) (M/M/ ∞) : (GD/ ∞ / ∞)
 Derivation of the waiting time distribution for the (M/M/1):(FCFS/ ∞ / ∞) model

(Ref. 6)

i) Definition and properties of Moment Generating Function of two random variables of continuous and discrete type. Necessary and sufficient condition for independence of two random variables.

ii) Trinomial distribution:

Definition of joint probability distribution (X,Y). Joint moment generating function, moments μ_{rs} where $r=0,1,2$ and $s=0,1,2$
Marginal & conditional distributions. Their Means & Variances.
Correlation coefficient between the random variables.
Distribution of the Sum $X+Y$.

iii) Extension to Multinomial distribution with parameters $(n, p_1, p_2, \dots, p_{k-1})$ where $p_1 + p_2 + \dots + p_{k-1} + p_k = 1$: Definition of joint probability distribution Concept only.

(iv) Bivariate Normal distribution:

Definition of joint probability distribution (X,Y). Joint moment generating function, moments μ_{rs} where $r=0,1,2$ and $s=0,1,2$
Marginal & conditional distributions. Their Means & Variances.
Correlation coefficient between the random variables. Condition for the independence of X and Y. Distribution of $aX+bY$, where a and b are constants.

Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. Fisher's z - transformation.

Tests for i) $H_0 : \rho = \rho_0$ and ii) $H_0 : \rho_1 = \rho_2$. Confidence interval for ρ .

(Ref. 2,3,8)

TOPICS FOR PRACTICALS:

Ser. No.	Topic
1	Probability
2	Stochastic processes
3	Queueing theory
4	Chebychev's inequality
5	Order statistics
6	Generating functions
7	Trinomial & Multinomial distributions
8	Bivariate Normal distribution
9	Significance of correlation coefficient

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1. Feller W: An introduction to probability theory and its applications, Volume:1, Third edition, Wiley Eastern Limited.
2. Robert V. Hogg & Allen T. Craig: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (singapore) Pvt Ltd.
3. Alexander M Mood, Franklin A Graybill, Duane C. Boes: Introduction to the theory of statistics, Third edition , Mcgraw- Hill Series .
4. Hogg R. V. and Tanis E.A. : Probability and Statistical Inference, Fourth edition, McMillan Publishing Company
5. S C Gupta & V K Kapoor: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Taha H.A.: Operations Research: An introduction, Eighth edition, Prentice Hall of India Pvt. Ltd.
7. J Medhi : Stochastic Processes, Second edition, Wiley Eastern Ltd.
8. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
9. J. N. Kapur, H. C. Saxena : Mathematical Statistics, Fifteenth edition, S. Chand and Company

T.Y.B.Sc.

STATISTICS

PAPER- II

STATISTICAL INFERENCE

- Unit 1** POINT ESTIMATION: 30L
Problem of Estimation
Definitions of Statistic , Estimator and Estimate
Properties of a good estimator: Unbiasedness, Consistency.
Efficient estimator; Minimum variance unbiased (MVU) estimator,
Uniqueness property of MVUE.
Sufficiency, Neymann Factorization Theorem (without proof)
Cramer Rao Inequality, Cramer Rao Lower Bound (CRLB), Definition of
Efficient estimator using CRLB
(Ref.1)
- Unit 2** METHODS OF ESTIMATION: 30L
Method of Maximum Likelihood Estimation (M.L.E.), Properties of M.L.E.
Method of Moments
Method of Minimum Chi-square and Modified Minimum Chi-square
(Ref.1)

BAYESIAN ESTIMATION:
Prior distribution, Posterior distribution, Loss function, Risk function,
Baye's solution under Squared Error Loss Function (SELF) and
Absolute Error Loss function.
(Ref.1)

INTERVAL ESTIMATION:
Concept of Confidence Interval and Confidence Limits
Definition of pivotal quantity and its use in obtaining confidence limits
Derivation of $100(1-\alpha)\%$ equal tailed confidence interval for the parameters
 μ , $\mu_1 - \mu_2$ (Based on Large and Small samples) , σ^2 , σ_1^2 / σ_2^2 of Normal
distribution.
Confidence Intervals based on asymptotic property of m.l.e. for Poisson and
Exponential distribution
(Ref. 1)
- Unit 3** TESTING OF HYPOTHESIS: 30L
Statistical hypothesis. Problem of testing of hypothesis. Definitions and
illustrations of i) Simple hypothesis ii) Composite hypothesis iii) Null
Hypothesis iv) Alternative Hypothesis v) Test of hypothesis vi) Critical
region vii) Type I and Type II errors viii) Level of significance ix) p-value
x) size of the test xi) Power of the test xii) Power function of a test
xiii) Power curve.
Definition of most powerful test of size α for a simple hypothesis against a
simple alternative hypothesis. Neyman -Pearson fundamental lemma.
Definition of uniformly most powerful (UMP) test. Construction of UMP
test for one tailed alternative hypothesis.
(Ref. 1,2,6)

11



LIKELIHOOD RATIO TEST:

Likelihood ratio principle. Definition of the test statistic and its asymptotic distribution (statement only) Derivation of the test procedure for testing a composite hypothesis against a composite alternative hypothesis for the parameters μ and σ^2 of Normal distribution.

(Ref. 1)

Unit 4

NON PARAMETRIC TESTS:

Need for non parametric tests. Distinction between a parametric and a non parametric test. Advantages and Disadvantages of Non-Parametric Tests. Single sample and double sample nonparametric tests. i) Sign test ii) Wilcoxon's signed rank test. iii) Median test iv) Mann – Whitney – Wilcoxon test. v) Run test. Assumptions, justification of the test procedure, critical regions for one tailed and two tailed test procedures. Problems with no ties.

(Ref. 3)

SEQUENTIAL PROBABILITY RATIO TEST:

Sequential probability ratio test procedures for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size. Neyman- Pearson test procedure. Definition of Wald's SPRT of strength (α, β) . Problems based on standard distributions: Bernoulli, Poisson, Normal, Exponential. Graphical and tabular procedures for carrying out the tests.

(Ref. 1, 4)

TOPICS FOR PRACTICALS:

Ser. No.	Topic
1	Method of Moments
2	Method of Maximum Likelihood
3	Method of Modified Minimum Chi-square
4	Bayesian Estimation
5	Interval Estimation
6	Testing of Hypotheses
7	Likelihood Ratio Tests
8	Non Parametric Tests
9	Sequential Probability Ratio Test

REFERENCES:

1. Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition, London Macmillan Co. Ltd.
2. Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition, Delhi Pearson Education.
3. Daniel W.W. : Applied Non Parametric Statistics, First edition, Boston-Houghton Mifflin Company
4. Wald A.: Sequential Analysis, First edition, New York John Wiley & Sons
5. Biswas S.: Topics in Statistical Methodology, First edition, New Delhi Wiley eastern Ltd.
6. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition, New Delhi S. Chand & Company Ltd.

STATISTICS

PAPER III

APPLIED STATISTICS - I

- Unit 1** EPIDEMIC MODELS: 30L
- The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals. Deterministic model with removals. Threshold theorem. Host – vector model. Modified Threshold theorem. Carrier model. Chain binomial models. Reed – frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of p and its asymptotic variance for the households of sizes up to 4.
- (Ref.1)
- Unit 2** BIOASSAYS: 30L
- Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. Indirect assays. Dose-response relationship. Condition of similarity and Monotony. Linearizing transformations. Parallel line assays. Symmetrical 2K-point parallel line assays ($K=2,3$). Validity tests using orthogonal contrasts. Quantal assays. Tolerance distribution. Median effective dose ED_{50} and LD_{50} . Probit analysis.
- (Ref.2,3)
- CLINICAL TRIALS:
- Introduction to clinical trials: The need and ethics of clinical trials. Over view of phases (I-IV)
Common terminology used in clinical trials
Study Protocol, Case record/Report form. Blinding (Single/double)
Randomised controlled (Placebo/active controlled)
Study Designs (Parallel, Cross Over)
Types of Trials: Inferiority, Superiority and Equivalence. Multicentric Trial. Inclusion/Exclusion Criteria
Statistical tools: Analysis of parallel Design using Analysis of Variance. Concept of odds ratio. Sample size estimation.
- (Ref.4,5,6,7)
- Unit 3** INVENTORY CONTROL: 30L
- Deterministic Models: Single item static EOQ models for i) Constant rate of demand with instantaneous replenishment, with and without shortages. ii) Constant rate of demand with uniform rate of replenishment, with and without shortages. iii) Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks.
- Probabilistic models. – Single period with i) Instantaneous demand (discrete and continuous) without setup cost. ii) Uniform demand (discrete and continuous) without set up cost.
- (Ref 9,12,13)

GAME THEORY:

Definitions of Two person Zero Sum Game, Saddle Point, Value of the Game, Pure and Mixed strategy.

Optimal solution of two person zero sum games: Dominance property, Derivation of formulae for (2 x 2) game. Graphical solution of (2 x n) and (m x 2) games.

(Ref. 9)

Unit 4

REPLACEMENT:

Replacement of items that deteriorate with time and the value of money i) remains constant ii) changes with time using weighted average of costs. Replacement of items that fail completely. Individual replacement and Group replacement policies.

(Ref.13)

DECISION THEORY:

Decision making under uncertainty Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwicz α criterion, Minimax Regret criterion.

Decision making under risk: Expected Monetary value criterion, Expected Opportunity Loss Criterion, EPPI, EVPI. Bayesian Decision rule for Posterior analysis. Decision tree analysis along with Posterior probabilities.

(Ref.9)

TOPICS FOR PRACTICALS:

Ser. No.	Topic
1	Deterministic epidemic models
2	Chain Binomial models
3	Direct Assays
4	Parallel line Assay
5	Quantal Assays
6	Clinical Trials
7	Deterministic inventory models
8	Probabilistic inventory models
9	Game Theory
10	Replacement
11	Decision Theory

REFERENCES:

1. Bailey N.T.J. : The Mathematical theory of infectious diseases, Second edition, Charles Griffin and Co. London
2. Das M.N and Giri N.C. : Design and Analysis of Experiments, Second edition, Wiley Eastern
3. Finney D.J. : Statistical Methods in Biological Assays, First edition, Charles Griffin and Co. London
4. Sanford Bolton and Charles Bon : Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc.
5. Zar Jerrold H. : Biostatistical Analysis, Fourth edition, Pearson's education
6. Friedman L. M., Furburg C., Demets D. L. (1998) : Fundamentals of Clinical Trials, First edition, Springer Verlag.
7. Fleiss J. L. (1989). The Design and Analysis of Clinical Experiments, Second edition, Wiley and Sons
8. Taha H.A. : Operations Research, Sixth edition, Prentice Hall
9. N. D. Vora : Quantitative Techniques in Management, Third edition, McGraw Hill Companies
10. Bannerjee B. : Operation Research Techniques for Management, First edition, Business books
11. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
12. Kantiswarup, P.K. Gupta, Manmohan : Operations Research, Twelfth edition, Sultan Chand & sons
13. S. D. Sharma : Operations Research, Eighth edition, Kedarnath Ramnath & Co.

APPLIED STATISTICS - II

Unit 1

MORTALITY TABLES:

Various mortality functions. Probabilities of living and dying. The force of mortality. Estimation of μ_x from the mortality table. Laws of mortality: Gompertz's and Makeham's first law. Select and Ultimate mortality tables. Mortality table as a population model. Stationary population. Expectation of life and Average life at death. Central death rate.

(Ref.1,2)

COMPOUND INTEREST AND ANNUITIES CERTAIN:

Accumulated value and present value, nominal and effective rates of interest. Discount and discounted value, Varying rates of interest. Equation of value. Equated time of payment. Present and accumulated values of annuity certain (immediate and due) with and without deferment period. Present value for perpetuity (immediate and due) with and without deferment period. Present and accumulated values of i) increasing annuity iii) increasing annuity when successive installments form a) arithmetic progression b) geometric progression. iv) annuity with frequency different from that with which interest is convertible. Present value for increasing perpetuity (immediate and due). Redemption of loan.

(Ref.2)

Unit 2

ASSURANCE BENEFITS:

Present value of Assurance benefits in terms of commutation functions of i) pure endowment assurance ii) temporary assurance iii) endowment assurance iv) whole life assurance v) double endowment assurance vi) increasing temporary assurance vii) increasing whole life assurance viii) special endowment assurance ix) deferred temporary assurance x) deferred whole life assurance.

Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with and without deferment period. Present values of Variable and increasing life annuities(immediate and due)

Net premiums and Level annual premiums for the various assurance plans. Natural premiums. Office premiums.

(Ref1,2)

Unit 3

TIME SERIES:

Definition of Time series. Its components. Models of Time Series. Estimation of trend by i) Freehand curve method ii) Method of semi averages iii) Method of moving averages iv) Method of least squares.

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- v) Exponential smoothing method
 Estimation of seasonal component by i) Method of simple averages
 ii) Ratio to moving average method iii) Ratio to trend method
 (Ref.3,4)

SIMULATION:

Scope of simulation applications. Types of simulation. Monte Carlo Technique of Simulation. Elements of discrete event simulation. Generation of random numbers. Sampling from probability distribution. Inverse method. Generation of random observations from i) Uniform distribution ii) Exponential distribution iii) Gamma distribution iv) Normal distribution. Simulation techniques applied to inventory and Queueing models.

(Ref.6)

Unit 4

RELIABILITY:

30L

Concept of reliability, Hazard-rate. Bath tub curve. Failure time distributions :i) Exponential ii) Gamma iii) Weibull iv) Gumbel. Definitions of increasing (decreasing) failure rate. System Reliability Reliability of i)series ii) parallel system of independent components having exponential life distributions. Mean Time to Failure of a system (MTTF).

(Ref 8,9)

LINEAR REGRESSION:

Linear regression model with one or more explanatory variables. Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients, (for one and two explanatory variables models) Properties of least square estimators (without proof) Coefficient of determination R^2 and adjusted R^2 . Procedure of testing i) overall significance of the model ii) significance of individual coefficients iii) significance of incremental contribution of explanatory variable for two explanatory variables model. Confidence intervals for the regression coefficients. Autocorrelation: Concept, Detection using i) Run Test ii) Durbin Watson Test, Generalized least square (GLS) method. Heteroscedasticity: Concept, Detection using i) Spearman's rank correlation test. ii) Breusch-Pagan-Godfrey test. Weighted least square (WLS) estimators Multicollinearity: Concept, Detection using i) R square & t ratios ii) pair wise correlation between regressors iii) Variance Inflation Factor (VIF) Consequences of using OLS estimators in presence of autocorrelation, heteroscedasticity and multicollinearity.

(Ref.10,11)

TOPICS FOR PRACTICALS:

Ser. No.	Topic
1	Mortality tables .
2	Annuities
3	Life annuities
4	Assurance benefits
5	Time series
6	Simulation
7	Reliability
8	Multiple regression model
9	Autocorrelation, Heteroscedasticity, Multicollinearity

REFERENCES:

1. Neill A. : Life Contingencies, First edition, Heineman educational books London
2. Dixit S.P., Modi C.S., Joshi R.V. : Mathematical Basis of Life Assurance, First edition Insurance Institute of India
3. Gupta S. C. & Kapoor V. K. : Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.
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7. N. D. Vora : Quantitative Techniques in Management, Third edition, McGraw Hill Companies
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10. Damodar Gujrathi, Sangetha : Basic Econometrics,, Fourth edition, McGraw-Hill Companies
11. William Greene : Econometric Analysis (1991), First edition, McMillan Publishing Company

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12