AC 29/4/13
Item no. 4.5

UNIVERSITY OF MUMBAI

Revised Syllabus

Sem. V & Sem. VI

Program: B.A.

Course: STATISTICS

(As per Credit Based Semester and Grading System with effect from the academic year 2013–2014)

T.Y.B.A. STATISTICS Syllabus

Restructured for Credit Based and Grading System

To be implemented from the Academic year 2013-2014

Schemes for T.Y.B.A STATISTICS

1)Scheme A : Students who have opted for ONE paper at F.Y.B.A.Statistics(Namely Scheme A)andTWO papers at S.Y.B.A.Statistics(Namely Scheme A) will opt for THREE papers atT.Y.B.A. Statistics (3Units) (Namely Scheme A)

2)Scheme B: Students who have opted for TWO papers at F.Y.B.A.Statistics(Namely Scheme B)and THREE papers at S.Y.B.A. Statistics (Namely Scheme B) will opt for Six papers atT.Y.B.A. Statistics (Namely Scheme B)

SCHEME A

T.Y.B.A. STATISTICS Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2013-2014

SEMESTER V
Theory

Course	UNIT	TOPICS	Credits	L / Week
UASTA 501	I	Univariate Random Variables. (Discrete and Continuous)	3	1
	II	Standard Discrete Probability Distributions.		1
	III	Bivariate Probability Distributions		1
UASTA 502	I	Concepts of Sampling and Simple Random Sampling.	3	1
	II	Stratified Sampling.		1
	III	Ratio and Regression Estimation.		1
UASTA503	I	Mortality Tables	3	1
	II	Compound Interest and Annuities Certain		1
	III	Assurance Benefits		1

Practical

UASTA P5	Practical of Course UASTA 501,Course UASTA 502,Course UASTA 503	3	6

T.Y.B.A. STATISTICS Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2013-2014

SEMESTER VI
Theory

Course	UNIT	TOPICS	Credits	L / Week
UASTA 601	I	Standard Continuous Probability Distributions.	3	1
	II	Normal Distribution.		1
	III	Exact Sampling Distributions.		1
UASTA 602	I	Analysis Of Variance.	3	1
	II	Design Of Experiments, Completely Randomized Design & Randomized Block Design.		1
	III	Latin Square Design & Factorial Experiments.		1
UASTA 603	I	Simulation	3	1
	II	Game Theory and Decision Theory		1
	III	Linear Regression Model		1

Practical

UASTA P05	Practical of Course UASTA 601+ Course UASTA 602 + Course UASTA 603	3	6

Semester V

Course Code	Title	Credits
UASTA 501	**PROBABILITY DISTRIBUTIONS**	**3 Credits (45 lectures)**
Unit I : Univariate Random Variables (Discrete and Continuous): Moment Generating Function, Cumulant generating Function-Their important properties. Relationship between moments and cumulants and their uses. Characteristic Function- Its properties (without proof). Transformation of random Variable		**15 Lectures**
Unit II : Standard Discrete Probability Distributions: Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative Binomial &Hypergeometric distributions. The following aspects of the above distributions(wherever applicable) to be discussed: Mean, Mode and Standard deviation. Moment Generating Function, Cumulant Generating Function, Additive property, Recurrence relation for central Moments, Skewness and Kurtosis (without proof), Limiting distribution.		**15 Lectures**
Unit III : Bivariate Probability Distributions: Joint Probability mass function for Discrete random variables**,**Joint Probability density functionfor continuous random variables. Their properties. Marginal and conditional Distributions. Independence of Random Variables. Conditional Expectation & Variance. Regression Function. Coefficient of Correlation. Transformation of Random Variables and Jacobian of transformation with illustrations.		**15 Lectures**

REFERENCES:

1.MoodA. M., GraybillF.A., Boyes D. C.: Introduction to the theory of statistics, Third Edition; McGraw-Hill Book Company.

2.HoggR.V., Craig A.T.:Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.

3..Hogg R.V., Tannis, E. A.:Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.

4.Miller I., MillerM.: .John E. Freund's Mathematical Statistics; Sixth Edition; Pearson Education Inc.

5.HoelP.G.; Fourth Edition Introduction to Mathematical Statistics; John Wiley & Sons Inc.

6.GuptaS.C., Kapoor V.K.:Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.

7.KapurJ.N., Saxena H.C.: Mathematical Statistics, Fifteenth Edition; S. Chand & Company Ltd.

8.MedhiJ. :Statistical Methods: An Introductory Text; Second edition; Wiley Eastern Ltd.

9.GoonA.M., GuptaM.K., DasGupta B. :An Outline of Statistical Theory Vol. 1; Third Edition; The World Press Pvt. Ltd.

Course Code	Title	Credits
UASTA 502	**THEORY OF SAMPLING**	**3 Credits (45 lectures)**
Unit I : **Simple Random Sampling:**(SRS). Simple Random Sampling for Variables: Definition, Sampling with & without replacement (WR/WOR). Lottery method & use of Random numbers to select Simple random sample. Estimation of population mean & total. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators. (WR/WOR). Simple Random Sampling for Attributes: Estimation of population proportion. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators. (WR/WOR). Estimation of Sample size based on a desired accuracy in case of SRS for variables & attributes. (WR/WOR).		**15 Lectures**
Unit II : **Stratified Sampling:** Need for Stratification of population with suitable examples. Definition of Stratified Sample. Advantages of stratified Sampling. **Stratified Random Sampling:** Estimation of population mean& total in case of Stratified Random Sampling (WOR within each strata). Expectation & Variance of the unbiased estimators, Unbiased estimators of variances of these estimators. Proportional allocation, Optimum allocation with and without varying costs. Comparison of Simple Random Sampling, Stratified Random Sampling using Proportional allocation &Neyman allocation.		**15 Lectures**
Unit III : **Ratio & Regression Estimation assuming SRSWOR:** Ratio Estimators for population Ratio, Mean & Total. Expectation & MSE of the Estimators. Estimators of MSE. Uses of Ratio Estimator. Regression Estimators for population Mean & Total. Expectation & Variance of the Estimators assuming known value of regression coefficient 'b'. Estimation of 'b'. Resulting variance of the estimators. Uses of regression Estimator.Comparison of Ratio, Regression & mean per Unit estimators.		**15 Lectures**

REFERENCES:

1. Cochran W.G.:Sampling Techniques; 3rd Edition; Wiley(1978)
2. Murthy M.N.:Sampling Theory and methods; Statistical Publishing Society. (1967)
3. Des Raj:Sampling Theory; McGraw Hill Series in Probability and Statistics. (1968).
4. Sukhatme P.V. and Sukhatme B.V.:Sampling Theory of Surveys with Applications; 3rd Edition; Iowa State University Press (1984).
5. Gupta S. C. andKapoor V.K.:Fundamentals of Applied Statistics; 3rd Edition; Sultan Chand and Sons (2001).
6. SinghDaroga, Chaudhary F.S.: Theory and Analysis of Sample Survey Designs:, Wiley Eastern Ltd. (1986).
7. Sampath S.: Sampling Theory and Methods, Second Edition (2005),Narosa.
8. MukhopadhyayParimal:Theory and Methods of Survey Sampling, (1998),Prentice Hall Of India Pvt. Ltd.

Course Code	Title	Credits
UASTA 503	**APPLIED STATISTICS-I**	**3 Credits (45 lectures)**
Unit I : Mortality Tables: Various Mortality functions. Probabilities of living and dying. The force of mortality. Estimation of μ_x from the mortality table. Mortality table as a population model. Stationary population. Expectation of life and Average life at death. Central Death rate.		**15 Lectures**
Unit II: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 and accumulated values of i) increasing annuity ii) increasing annuity when successive instalment form a) arithmetic progression b) geometric progression. Redemption of loan		**15 Lectures**
Unit III : Assurance Benefits: Present value of Assurance benefits in terms of commutation functions ofi) Pure endowment assurance, ii) Temporary assurance, iii) Endowment assurance, iv) Whole life assurance, v) Special endowment assurance, vi) Deferred temporary assurance, vii) Deferred whole life assurance Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) Net Level annual premiums for the assurance plans mentioned above.		**15 Lectures**

References:

1. Neil 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.: Fundamental of Applied Statistics, Fourth edition, Sultan Chand and Sons, India

DISTRIBUTION OF TOPICS FOR PRACTICALS
SEMESTER-V
COURSE CODE UASTA P5

Sr. No.	SEMESTER V Course UASTAP5(A)
1.	Moment Generating Function, Moments.
2.	Cumulant generating Function, Cumulants
3.	Standard Discrete Distributions.
4.	Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation
5.	Transformation of discrete & continuous random variables.

Sr. No.	SEMESTER V Course UASTAP5(B)
1.	Simple Random Sampling for Variables.
2.	Simple Random Sampling for Attributes.
3.	Estimation of Sample Size in Simple Random Sampling.
4.	Stratified Random Sampling.
5.	Ratio and RegressionEstimation.

Sr. No.	Semester V Course UASTAP5(C)
1.	Mortality Tables
2.	Compound Interest
3.	Annuities Certain
4.	Life Annuities
5.	Assurance Benefits

Semester VI

Course Code	Title	Credits
UASTA 601	**PROBABILITY AND SAMPLING DISTRIBUTIONS**	**3 Credits (45 lectures)**
Unit I : Standard Continuous Probability Distributions: Rectangular, Triangular, Exponential, Gamma (with Single & Double parameter), Beta (Type I & TypeII). The following aspects of the above distributions(wherever applicable) to be discussed: Mean, Median, Mode & Standard deviation. Moment Generating Function, Additive property, Cumulant Generating Function. Skewness and Kurtosis (without proof). Interrelation between the distributions. **Normal Distribution:** Mean, Median, Mode, Standard deviation, Moment Generating function, Cumulant Generating function, Moments &Cumulants (up to fourth order). Recurrence relation for central moments, skewness& kurtosis, Mean absolute deviation. Distribution of linear function of independent Normal variables. Fitting of Normal Distribution. Central Limit theorem for i.i.d. randomvariables. Log Normal Distribution: Derivation of mean & variance.		**15 Lectures**
Unit II : Chi-Square Distribution: Concept of degrees of freedom. Mean, Median, Mode & Standard deviation. Moment generating function, Cumulant generating function. Additive property, Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution (without proof). **Applications of Chi-Square:** Test of significance for specified value of variance of a Normal population. Test for goodness of fit & Test for independence of attributes (derivation of test statistics is not expected), Yates' correction.		**15 Lectures**

Unit III: <u>t-distribution:</u> Mean, Median, Mode & Standard deviation. Distribution of ratio of a Standard Normal variable to the square root of an independent Chi-square divided by its degrees of freedom. Asymptotic properties. Student's t. **<u>Applications of t:</u>** Confidence interval for: Mean of Normal population, difference between means of two independent Normal populations having the same variance. Test of significance of: mean of a Normal population, difference in means of two Normal populations (based on: (i) independent samples with equal variances. (ii) dependent samples). **<u>F-distribution:</u>** Mean, Mode & Standard deviation. Distribution of : Reciprocal of an F variate, Ratio of two independent Chi-squares divided by their respective degrees of freedom. Interrelationship of F with: t-distribution, Chi-square distribution & Normal distribution. **<u>Applications of F:</u>** Test for equality of variances of two independent Normal populations.	**15 Lectures**

<u>REFERENCES:</u>

1. MoodA. M., GraybillF.A., Boyes D. C.: Introduction to the theory of statistics, Third Edition; McGraw-Hill Book Company.
2. HoggR.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
3. Hogg R.V., Tannis, E. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
4. Miller I., MillerM.: .John E. Freund's Mathematical Statistics; Sixth Edition; Pearson Education Inc.
5. HoelP.G.; Fourth Edition Introduction to Mathematical Statistics; John Wiley & Sons Inc.
6. GuptaS.C., Kapoor V.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
7. KapurJ.N., Saxena H.C.: Mathematical Statistics, Fifteenth Edition; S. Chand & Company Ltd.
8. MedhiJ. : Statistical Methods: An Introductory Text; Second edition; Wiley Eastern Ltd.
9. GoonA.M., GuptaM.K., DasGupta B. :An Outline of Statistical Theory Vol. 1; Third Edition; The World Press Pvt. Ltd.

Course Code	Title	Credits
UASTA 602	**ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS**	**3 Credits (45 lectures)**
Unit I : Analysis of Variance: Introduction, Uses, Cochran's Theorem (Statement only). One way classification with equal & unequal observations per class, Two way classification with one observation per cell. Mathematical Model, Assumptions, Expectation of various sums of squares, F- test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard Error and Confidence limits for elementary treatment contrasts.		**15 Lectures**
Unit II : Design Of Experiments: Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. Principles of Design of Experiments: Replication, Randomization & Local Control. Efficiency of design D1 with respect to design D2. Choice of size, shape of plots & blocks in agricultural &non-agricultural experiments. **Completely Randomized Design (CRD) & Randomized Block Design (RBD):** Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of RBD relative to a CRD.		**15 Lectures**
Unit III : Latin Square Design (LSD): Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table.Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. Efficiency of the design relative to RBD, CRD.Missing plot technique for one missing observation in case of RBD & LSD **Factorial Experiments:** Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Yates' method. Analysis of 2^2& 2^3 factorial Experiments.		**15 Lectures**

REFERENCES

1. Cochran W.G. and Cox G.M.: Experimental Designs; Second Edition;John Wiley and Sons.
2. KempthorneOscar :The Design and Analysis of Experiments, John Wiley and Sons.
3. Montgomery Douglas C.:Design and Analysis of Experiments; 6th Edition;John Wiley & Sons.
4. Das M.N.and Giri N.C.: Design and Analysis of Experiments, 2nd Edition; New Age International (P) Limited;1986.
5. Federer Walter T.:Experimental Design, Theory and Application; Oxford & IBH Publishing Co. Pvt. Ltd.
6. Gupta S.C.and Kapoor V.K.: Fundamentals of Applied Statistics; 3rd Edition; Sultan Chand and Sons (2001).
7. Winer B.J.:Statistical Principles in Experimental Design, McGraw Hill Book Company.

Course Code	Title	Credits
UASTA 603	**APPLIED STATISTICS-II**	**3 Credits (45 lectures)**
Unit I : 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. Concepts of Inventory problems. Simulation technique applied to inventory and queuing models.		**15 Lectures**
Unit II : 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 (2x2) game. Graphical solution of (Mx2) and (2xN) games. **Decision Theory:** Decision making under uncertainty: Laplace criterion, Maximax (Minimin) Criterion, Maximin criterion, Hurwicz criterion, Minimax Regret criterion. Decision making under Risk: Expected Monetary value criterion, Expected opportunity loss criterion, EPPI, EVPI, Decision Tree analysis.		**15 Lectures**
Unit III : Linear Regression Model: Multiple Linear Regression Model with two independent variables: Assumptions of the model, Derivation of ordinary least square (OLS) estimators of the regression coefficients, Properties of least square estimators (without proof), Concept of R^2 and adjusted R^2. Procedure of testing of (i) Overall significance of the model, (ii) significance of individual coefficients, (iii) significance of contribution of additional independent variable to the model, Confidence Intervals for the regression coefficients. Concepts of Autocorrelation, Heteroscedasticity, Multicollinearity		**15 Lectures**

REFERENCES

1.GujrathiDamodar, Sangetha:Basic Econometrics: , Fourth edition, McGraw-Hill Companies

2. Kantiswaroop and Gupta Manmohan:Operations Research, 4th Edition; S Chand & Sons.

3. BrosonRichard :Schaum Series book in O.R., 2nd edition Tata Mcgraw Hill Publishing Company Ltd.

4. SasieniMaurice, Yaspan Arthur and Friedman Lawrence: Operations Research: Methods and Problems,(1959), John Wiley & Sons.

5. Sharma J K.:Mathematical Models in Operations Research, (1989), Tata McGraw Hill Publishing Company Ltd.
6. Sharma S.D.: Operations Research, 11th edition, KedarNath Ram Nath& Company.
7. Taha H. A.: Operations Research:., 6th edition, Prentice Hall of India.
8.Sharma J.K.: Quantitative Techniques For Managerial Decisions, (2001), MacMillan India Ltd.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-VI
COURSE CODE UASTA P6

Sr. No	Semester VI Course UASTA P6(A)
1.	Standard Continuous distributions.
2.	Normal Distribution.
3.	Chi Square distribution.
4.	t distribution.
5.	F distribution.

Sr. No	Semester VI Course UASTA P6(B)
1	Analysis of Variance- One Way.
2	Analysis of Variance- Two Way.
3	Completely Randomized Design.
4	Randomized Block Design.
5	Latin Square Design.
6	Factorial Experiments.

Sr. No	Semester VI Course UASTA P6(C)
1	Simulation
2	Game Theory
3	Decision Theory
4	Multiple Linear Regression

Internal Assessment of Theory Core Courses Per Semester Per Course

1. One Assignment: …….. 10 Marks
2. One Class Test: …….20 Marks.
3. Active participation in class instructional deliveries:……..…05 Marks.
4. Overall conduct as a responsible student, mannerism etc:…. .05 Marks.

Semester End Examination

Theory: At the end of the semester, examination of **TWO** hours duration and 60 marks based on the three units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for **each course**:

There shall be Fourcompulsory Questions of fifteen marks each.

Practicals: At the end of the semester, examination of 2 hours duration and 25 marks shall be held for **each course**.

Pattern of the Practical Paperfor each course:

Question	Sub question	Based on	Marks
1	A or A	Unit 1	7
2	B or B	Unit 2	7
3	C or C	Unit 3	7
4	D or D or D	All units	4

1. Semester work, Documentation, Journal ……..…. 15Marks.
2. Viva ……10 Marks.

Workload

Theory :3 lectures per week per course.
Practicals: 3 lecture periods per course per week per batch. Both lecture periods of the practical shall be conducted in succession together on a single day.

SCHEME B

1) Those students who have opted this scheme for Statistics at T.Y.B.A. will have SIX papers in Statistics.

2) These students of T.Y.B.A. will have teaching and evaluation along with the corresponding T.Y. B. Sc. students of Statistics.

The course codes and evaluation for those T.Y.B.A. (Statistics) Scheme B will be as mentioned below.

SEMESTER V

Theory

Course	UNIT	TOPICS	Credits	L / Week
USSTB 501	I	Probability-I	2.5	1
	II	Probability-II		1
	III	Joint Moment Generating Function Trinomial & Multinomial Distribution		1
	IV	Order Statistics		1
USSTB 502	I	Point Estimation and Properties of Estimator- I	2.5	1
	II	Properties of Estimator- II		1
	III	Methods of Estimation		1
	IV	Bayesian Estimation and Confidence Interval		1
USSTB 503	I	Epidemic Models	2.5	1
	II	Bioassay		1
	III	Clinical Trials		1
	IV	Bioequivalence		1
USSTB504	I	Mortality Tables	2.5	1
	II	Compound Interest And Annuities Certain		1
	III	Life Annuities		1
	IV	Assurance Benefits		1

Course	PRACTICALS	Credits	L / Week
USSTBP05	**Practicals of Course USST501 + Course USST502**	**3**	**8**
USSTBP06	**Practicals of Course USST503 + Course USST504**	**3**	**8**

Course Code	Title	Credits
USSTB501	**PROBABILITYAND DISTRIBUTIONTHEORY**	**2.5 Credits (60 lectures)**
Unit I : PROBABILITY I **(**i) Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. (ii) Mathematical, Statistical, Axiomatic and Subjective probability. (iii) Sub populations and partitions. Derivation of a) $A_{r,n}$:Number of distinguishable distributions of putting r indistinguishable balls in n cells; b) Number of distinguishable distributions of putting r indistinguishable balls in n cells such that no cell is empty. (iv) Ordered samples and runs. (v) Probabilities based on a) Maxwell Boltzmann, Bose Einstein and Fermi Dirac Statistics. (vi) Addition Theorem for (a) two (b) three events. (Ref. 1,2,5,7,8)		**15 Lectures**
Unit II :PROBABILITY II (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…A_N. Matching and Guessing problems. (ii) Conditional Probability: Multiplication Theorem for two, three events. Independence of two/three events - complete and pair wise. (iii) Bayes' theorem. (Ref. 1,2,5,8)		**15 Lectures**
Unit III: JOINT MGF, TRINOMIAL AND MULTINOMIAL DISTRIBUTION (i) Definition and properties of Moment Generating Function (MGF) of two random variables of discrete andcontinuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Multivariate MGF. **(ii) Trinomial distribution:** Definition of joint probability distribution of (X, Y). Joint moment generating		**15 Lectures**

function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y). Distribution of the Sum X+Y. (iii) Extension to Multinomial distribution with parameters (n, p_1, p_2,…p_{k-1}) where $p_1+ p_2,+…p_{k-1}+ p_k= 1$. Expression for joint MGF. Derivation of:joint probability distribution of (X_i, Xj). Conditional probability distribution of X_i given $X_j = x_j$(Ref.2,3,6)	
Unit IV: ORDER STATISTICS (i) Definition of Order Statistics based on a random sample. (ii) Derivation of: (a) Cumulative distribution function of r^{th}order statistic. (b) Probability density functions of the r^{th} order statistic. (c) Joint Probability density function of the r^{th} and the s^{th} order statistic (r<s) (d) Joint Probability density function of all n ordered statistics. (iii) Probability density function of Median (in the case of odd sample sizes) and Range for Uniform and Exponential distributions. (Ref.2,3,4)	**15 Lectures**

REFERENCES

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R V. & CraigAllen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
3. MoodA. M., GraybillF. A., BoesD. C.: 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. Gupta S C &KapoorV K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Biswas S.: Topics in Statistical Methodology,First edition, Wiley Eastern Ltd.
7. KapurJ. N.&Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
8. ChandraT.K.&ChatterjeeD.: A First Course in Probability, Second Edition, Narosa Publishing House.

Course Code	Title	Credits

USSTB502	THEORY OF ESTIMATION	2.5 credits 60 Lectures

Unit I: ESTIMATION AND PROPERTIES OF ESTIMATOR- I — **15 Lectures**

Notion of a parameter and parameter space. Problem of Estimation,
Definitions of Statistic, Estimator and Estimate.
Properties of a good estimator:

(a) Unbiasedness: Definition of an unbiased estimator, biasedestimator, positive and negative bias, illustrations and examples (these should include unbiased and biased estimators for the same parameters). Proofs of the following results regarding unbiased estimators.

(i) Two distinct unbiased estimators of $\varphi(\theta)$ give rise to infinitely many unbiased estimators.

(ii) If T is an unbiased estimator of θ , then $\varphi(T)$ is unbiasedestimator of $\varphi(\theta)$ provided $\varphi(.)$ is a linear function.

(b) Consistency: Definition, Proof of the following theorem: An estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity.

(c) Sufficiency: Concept and definition of Sufficiency, Neymann Factorization Theorem (without proof). Exponential family of probability distributions and Sufficient statistic.

(d) Relative efficiency of an estimator. Illustrative examples.

(Ref. 1,3,8)

Unit II : PROPERTIES OF ESTIMATOR- II — **15 Lectures**

Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE. Fisher information function**,** Statement and proof of Cramer-Rao inequality,Cramer–Rao Lower Bound(CRLB), Definition of minimum variance bound unbiased estimator (MVBUE) of $\phi(\theta)$.Definition of Efficient estimator using CRLB.(Ref. 1,3,8)

Unit III : METHODS OF ESTIMATION — **15 Lectures**

a) Method of Maximum Likelihood Estimation (M.L.E.), Definition of likelihood as a function of unknown parameter, for a random sample from i) discrete distribution ii) continuous distribution. Distinction between likelihood function and jointp.d.f./ p.m.f.

Derivation of Maximum Likelihood Estimator (M.L.E.) for parameters of standard distributions (case of one and two unknown parameters). Properties of M.L.E(without proof)

b) Method of Moments, Derivation of moment estimators for standard distributions (case of one and two unknown parameters). Illustrations of situations where M.L.E. and Moment Estimators are distinct and their comparison using Mean Square Error.

c) Method of Minimum Chi-square and Modified Minimum Chi-square.

(Ref. 1,3,8)	
Unit IV : BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL **Bayesian Estimation**: Prior distribution, Posterior distribution, Loss function, Risk function, Baye's solution under Squared Error Loss Function (SELF) and Absolute Error Loss function. **Interval Estimation**: Concept of Confidence Interval and Confidence Limits. Definition of pivotal quantity and its use in obtaining confidence limits. Derivation of 100(1-α)% equal tailed confidence interval for the parameters μ, $\mu_1 - \mu_2$ (Population variance(s) known / unknown), $\sigma^2, \sigma_1^2/\sigma_2^2$(Normal distribution).Confidence Intervals based on asymptotic property of M.L.E. Confidence interval for the parameters of Poisson and Exponential distribution. Equidistant confidence interval for θ based on the random sample from Uniform distribution$(0,\theta)$ by using distribution of M.L.E. (Ref. 1, 3, 8).	**15 Lectures**

REFERENCES:

1. HoggR.V., CraigA.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
2. HoggR.V., TannisE. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
3. Rohatgi, V. K, EhsanesSaleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics , Second Edition, Wiley series in Probability and Statistics.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. HoelP.G.: Introduction to Mathematical Statistics; Fourth Edition; John Wiley & Sons Inc.
6. GuptaS.C., KapoorV.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
7. KapurJ.N., SaxenaH.C.:Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
8. Arora Sanjay and BansiLal : New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi,5(1989
9. Pawagi V.R.&RanadeSaroj A.: Statistical Methods Using R Software;NiraliPublications.

Course Code	Title	Credits

USSTB503	**BIOSTATISTICS**	**2.5 Credits (60 lectures)**

Unit I : EPIDEMIC MODELS — **15 Lectures**

(i) The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals, Carrier model.

(ii) 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 households of sizes up to 4.

(Ref.1)

Unit II: BIOASSAYS — **15 Lectures**

i) Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem.

ii) Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit analysis.

iii) Indirect assays. Dose-response relationship .Condition of similarity and Monotony. Linearizing transformations. Parallel line assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency.

(Ref.2,3)

Unit III: CLINICAL TRIALS: AN INTRODUCTION — **15 Lectures**

Introduction to clinical trials: The need and ethics of clinical trials.
Common terminology used in clinical trials. Over view of phases (I-IV)
Study Protocol, Case record/Report form, Blinding (Single/Double)
Randomized 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. 4,5,6,7,8)

Unit IV:BIOEQUIVALENCE — **15 Lectures**

Definitions of Generic Drug product. Bioavailability, Bioequivalence,
Pharmakokinetic (PK) parameters C_{max}, AUC_t, $AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}.
Estimation of PK parameters using 'time vs. concentration' profiles.
Designs in Bioequivalence: Parallel, Cross over (Concept only).
Advantages of Crossover design over Parallel design.
Analysis of Parallel design using logarithmic transformation (Summary statistics, ANOVA and 90% confidence interval).
Confidence Interval approach to establish bioequivalence (80/125 rule).

(Ref. 9)

***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. Boltan Sanford and Bon Charles: Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc.
5. Zar Jerrold H.: Biostatistical Analysis, Fourth edition, Pearson's education.
6. Daniel Wayne W: Biostatistics- A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley Series in Probability and Statistics.
7. Friedman L. M., Furburg C., Demets D. L.: Fundamentals of Clinical Trials, First edition, Springer Verlag.
8. Fleiss J. L. The Design and Analysis of Clinical Experiments, Second edition, Wiley and Sons
9. Shein-Chung-Chow: Design and Analysis of Bioavailability & Bioequivalence studies, Third Edition, Chapman & Hall/CRC Biostatistics series.

Course Code	Title	Credits
USSTB504	**ELEMENTS OF ACTUARIAL SCIENCE**	**2.5 Credits (60 lectures)**
Unit I : 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, Ultimate and Aggregate mortality tables. Stationary population. Expectation of life and Average life at death. (Ref.2,3)		**15 Lectures**
Unit II:COMPOUND INTEREST AND ANNUITIES CERTAIN: Accumulated value and present value, nominal and effective rates of interest. 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;(ii) increasing annuity whensuccessive installments form arithmetic progression;(iii) annuity with Frequencydifferent from that with which interest is convertible. Redemption of loan. (Ref.2)		**15 Lectures**
Unit III: LIFE ANNUITIES: 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, increasing life annuities and increasing Temporary life annuities (immediate and due).(Ref:1,2)		**15 Lectures**
Unit IV: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) special endowment assurance; (vi) deferred temporary assurance. Net premiums ,Net level annual premiums (including limited period of payment) for the various assurance plans. Office premiums. (Ref:1,2)		**15 Lectures**

***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.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-V

COURSE CODE USSTBP05

Sr. No.	Practical Topics (from Course USSTB501)
5.1.1	Probability-1
5.1.2	Probability -2
5.1.3	Probability -3
5.1.4	Multinomial Distribution
5.1.5	Order Statistics -1
5.1.6	Order Statistics -2

Sr. No.	Practical Topics (from Course USSTB502)
5.2.1	MVUE and MVBUE
5.2.2	Method of Estimation -1
5.2.3	Method of Estimation -2
5.2.4	Bayes Estimation
5.2.5	Confidence Interval
5.2.6	Use of R software

COURSE CODE USSTBP06

Sr. No.	Practical Topics (from Course USSTB503)
5.3.1	Epidemic models
5.3.2	Direct Assays
5.3.3	Quantal Assays
5.3.4	Parallel line Assay
5.3.5	Clinical Trials
5.3.6	Bioequivalence

Sr. No.	Practical Topics (from Course USSTB504)
5.4.1	Mortality tables 1
5.4.2	Mortality tables 2
5.4.3	Annuities 1
5.4.4	Annuities 2
5.4.5	Life annuities
5.4.6	Assurance benefits

SEMESTER VI

Theory

Course	UNIT	TOPICS	Credits	L / Week
USSTB601	I	Bivariate Normal Distribution	2.5	1
	II	Generating Functions		1
	III	Stochastic Processes		1
	IV	Queuing Theory		1
USSTB602	I	Introduction to Testing of Hypothesis	2.5	1
	II	Parametric tests		1
	III	Likelihood Ratio Test and SPRT		1
	IV	Non-Parametric tests		1
USSTB603	I	Inventory Control	2.5	1
	II	Game Theory		1
	III	Replacement		1
	IV	Decision Theory		1
USSTB604	I	Time Series	2.5	1
	II	Simulation		1
	III	Linear Regression		1
	IV	Reliability		1

Course	PRACTICALS	Credits	L / Week
USSTBP07	Practicals of Course USST601 + Course USST602	3	8
USSTBP08	Practicals of Course USST603 + Course USST604	3	8

Course Code	Title	Credits

USSTB601	**DISTRIBUTIONTHEORY AND STOCHASTIC PROCESSES**	2.5 Credits (60 lectures)

Unit I : BIVARIATE NORMAL DISTRIBUTION — **15 Lectures**

i) 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.
Necessary and sufficient condition for the independence of X and Y.
Distribution of aX+bY, where 'a' and 'b' are constants.

ii) Distribution of sample correlation coefficient when $\rho = 0$.
Testing the significance of a correlation coefficient.
Fisher's z – transformation.
Tests for i) $H_0: \rho = \rho_0$ ii) $H_0: \rho_1 = \rho_2$
Confidence interval forρ.

(Ref.2,3,6)

Unit II :GENERATING FUNCTIONS — **15 Lectures**

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 III: STOCHASTIC PROCESSES — **15 Lectures**

Definition of stochastic process. Postulates and difference differential equations for : (i) Pure birth process (ii) Poisson process with initially 'a' members, for a =0 and a >0 (iii) Yule Furry 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), mean and variance where ever applicable.

(Ref.1,7)

Unit IV: QUEUINGTHEORY — **15 Lectures**

Basic elements of the Queuing model.
Roles of the Poisson and Exponential distributions.
Derivation of Steady state probabilities for birth and death process. Steady state probabilities and 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/∞) : (GD/ ∞ /∞) (Ref.6)

REFERENCES:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & CraigA.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.
3. Mood A M, Graybill F A, Bose D C: 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. Gupta S C &KapoorV K: 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. MedhiJ: Stochastic Processes, Second edition, Wiley Eastern Ltd.
8. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
9. KapurJ. N., SaxenaH. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company

Course Code	Title	Credits
USSTB602	**TESTING OF HYPOTHESES**	2.5 credits 60 Lectures
Unit I : MOST POWERFUL TESTS 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. (Ref. 1,2)		**15 Lectures**
Unit II : UNIFORMLY MOST POWERFUL AND LIKELIHOOD RATIO TESTS Definition,Existence and Construction of uniformly most powerful (UMP) test. Likelihood ratio principle. Definition of test statistic and its asymptotic distribution (statement only). Construction of LRT for the mean of normal distribution for i) known σ^2 ii) unknown σ^2 (two sided alternatives). LRT for variance of normal distribution for i) known μ ii) unknown μ (two sided alternatives hypotheses). Ref. (1,2,3)		**15 Lectures**
Unit III : SEQUENTIAL PROBABILITY RATIO TEST(SPRT) Sequential test procedure 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 Bernoulli, Binomial, Poisson, Normal, Exponential distributions. Graphical /tabular procedure for carrying out the tests. (Ref. 1,6,8,9)		**15 Lectures**
Unit IV : NON-PARAMETRIC TESTS Need for non-parametric tests. Distinction between a parametric and a non-parametric test .Concept of a distribution free statistic. Single sample and two sample Nonparametric tests. (i) Sign test (ii) Wilcoxon's signed rank test (iii) Median test(iv) Mann–Whitneytest (v) Run test. Assumptions, justification of the test procedure for small & large samples. (Ref.5)		**15 Lectures**

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. Lehmann, E. L: Testing of Statistical Hypothesis, Wiley &sons
4. Rao, C. R.: Linear Statistical Inference,
5. Daniel W.W.: Applied Non Parametric Statistics First edition Boston-Houghton Mifflin Company.
6. Wald A.: Sequential Analysis First edition New York John Wiley & Sons
7. Biswas S.: Topics in Statistical Methodology. First edition New Delhi Wiley eastern Ltd.
8. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics Tenth edition New Delhi S. Chand & Company Ltd.
9. Sanjay Arora and BansiLal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
10. Pawagi V. R. and RanadeSaroj A: Statistical Methods Using R Software.Nirali Publications.

Course Code	Title	Credits
USSTB603	**OPERATIONS RESEARCH TECHNIQUES**	**2.5 Credits (60 lectures)**
Unit I : INVENTORY CONTROL Introduction to Inventory Problem 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. 1,4,5)		**15 Lectures**
Unit II :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 (2x2) game. Graphical solution of (2xn) and (mx2) games. (Ref. 1)		**15 Lectures**
Unit III: REPLACEMENT Replacement of items that deteriorate with time and value of money i) remains constant ii) changes with time. Replacement of items that fail completely: Individual replacement and Group replacement policies. (Ref. 5)		**15 Lectures**
Unit IV: 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.1)		**15 Lectures**

REFERENCES:

1. VoraN. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies
2. Bannerjee B. : Operation Research Techniques for Management, First edition, Business books
3. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
4. Kantiswarup, P.K. Gupta, Manmohan : Operations Research, Twelth edition, Sultan Chand & sons
5. SharmaS. D.: Operations Research, Eighth edition, KedarnathRamnath& Co.

Course Code	Title	Credits
USSTB604	**FORECASTING & RELIABILITY**	**2.5 Credits (60 lectures)**
Unit I : 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. (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.1,2)		**15 Lectures**
Unit II :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.4,5)		**15 Lectures**
Unit III: 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 Durbin Watson Test, Generalized Least Square (GLS) method. Heteroscedasticity: Concept, Detection using Breusch-Pagan-Godfrey test. Weighted Least Square (WLS) estimators Multicollinearity:Concept, Detection using(i) R square & t ratios(ii) Variance Inflation Factor (VIF) (Ref: 8,9)		**15 Lectures**

Unit IV: RELIABILITY	**15 Lectures**
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 6,7)	

REFERENCES:

1. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand& Sons.
2. Sharma J. K.: Operations Research Theory and Application, Third edition, Macmillan India Ltd**.**
3. Spiegel M.R. : Theory and Problems of Statistics, Fourth edition, Schaum's Outline Series Tata McGraw Hill
4. TahaHamdy A. : Operations Research : Eighth edition, Prentice Hall of IndiaPvt. Ltd
5. VoraN. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies
6. Barlow R.E. and Prochan Frank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston
7. Mann N.R., Schafer R.E., Singapurwalla N.D.: Methods for Statistical Analysis of Reliability and Life Data, First edition, John Wiley & Sons.
8. GujrathiDamodar,S .Sangeetha: Basic Econometrics,, Fourth edition, McGraw-Hill Companies.
9. GreeneWilliam: Econometric Analysis,First edition, McMillan Publishing Company.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-VI

COURSE CODE USSTBP07

Sr. No.	Practical Topics (from Course USSTB601)
6.1.1	Bivariate Normal Distribution
6.1.2	Tests for correlation and Interval estimation
6.1.3	Generating Function
6.1.4	Stochastic Process
6.1.5	Queuing Theory -1
6.1.6	Queuing Theory -2

Sr. No.	Practical Topics (from Course USSTB602)
6.2.1	Testing of Hypothesis 1
6.2.2	Testing of Hypothesis-2
6.2.3	SPRT
6.2.4	Non Parametric test-1
6.2.5	Non Parametric test-2
6.2.6	Use of R software.

COURSE CODE USSTBP08

Sr. No.	Practical Topics (from Course USSTB603)
6.3.1	Inventory-1
6.3.2	Inventory-2
6.3.3	Game Theory
6.3.4	Replacement
6.3.5	Decision Theory-1
6.3.6	Decision Theory-2

Sr. No.	Practical Topics (from Course USSTB604)
6.4.1	Time series-1
6.4.2	Time series-2
6.4.3	Simulation
6.4.4	Reliability
6.4.5	Multiple regression model -1
6.4.6	Multiple regression model- 2

Internal Assessment of Theory Core Courses Per Semester Per Course

5. One Class Test …….. 20 Marks
6. One Assignment …….10 Marks.
7. Active participation in class instructional deliveries …..…05 Marks.
8. Overall conduct as a responsible student, mannerism etc . .05 Marks.

Semester End Examination- THEORY

At the end of the semester, examination of two hours duration and 60 marks based on the four units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for ***each course*** :

There shall be Five Questions of twelve marks each. All Questions to be Compulsory. Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III,Question 4 based on Unit IV andQuestion 5 based on all four Units combined. Every question to have two sub-questions of 12 marks each and students to attempt any one.

Internal Assessment of Practical Core Courses Per Semester per course

1. Semester work, Documentation, Journal ….05Marks.
2. Viva ……05 Marks.

Semester End Examination- PRACTICALS

At the end of the semester, examination of three hours duration and 40 marks shall be held for **each course**as shown below.

Practical course	Part A	Part B	Duration	Marks out of
USSTBP05	Questions from USSTB501	Questions from USSTB502	3 hours	40
USSTBP06	Questions from USSTB503	Questions from USSTB504	3 hours	40
USSTBP07	Questions from USSTB601	Questions from USSTB602	3 hours	40
USSTBP08	Questions from USSTB603	Questions from USSTB604	3 hours	40

Pattern of **Practical question** paper at the end of the semester for **each course**:
Every paper will consist of two parts A and B. Every **part** will consist of two questions of 20 marks each. Students to attempt one question from each part.

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