UNIVERSITY OF MUMBAI
No. UG/ 180 of 2016-17

CIRCULAR:-

A reference is invited to the Syllabi relating to the B.Sc. degree course , **vide** this office Circular No. UG/133 of 2011, dated 13th June, 2011 and the Principals of affiliated Colleges in Science are hereby informed that the recommendation made by the Board of Studies in Statistics at its meeting held on 14th June, 2016 has been accepted by the Academic Council meeting held on 14th July, 2016 **vide** item No. 4.85 and that in accordance therewith, the revised syllabus as per the Choice Based Credit System for F.Y. B.Sc. programme in Statistics (Sem. I &II), which are available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

MUMBAI – 400 032
22 November, 2016

(Dr.M.A.Khan)
REGISTRAR

To,

The Principals of the affiliated Colleges in Science.

A.C/4.85/14.07.2016

****

No. UG/ 180 -A of 2016 MUMBAI-400 032 22 November, 2016

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculties of Science,
2) The Chairman, Board of Studies in Zoology,
3) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
4) The Director, Board of College and University Development,
5) The Co-Ordinator, University Computerization Centre,
6) The Controller of Examinations.

(Dr.M.A.Khan)
REGISTRAR

PTO..

COURSE USST101: DESCRIPTIVE STATISTICS-1

Unit I - Types of Data and Data Condensation: a) Concept of population and sample. Finite ,Infinite population ,Notion of SRS ,SRSWOR and SRSWR b) Types of Characteristics, Different types of scales: nominal, ordinal, interval and ratio. c) Collection of Primary data: concept of a questionnaire and a schedule, Secondary data d) Types of data: Qualitative and quantitative data; Time series data and cross section data, discrete and continuous data. e) Tabulation. f) Dichotomous classification- for two and three attributes, Verification for consistency. g) Association of attributes: Yule's coefficient of association Q. Yule's coefficient of Colligation,	**15 Lectures**
Unit II–Classification of Data and Measures of central tendency **i)Classification of Data** a) Univariate frequency distribution of discrete and continuous variables. Cumulative frequency distribution. b) Graphical representation of frequency distribution by Histogram, frequency polygon, Cumulative frequency curve. Stem and leaf diagram. **ii)Measures of central tendency** a)Concept of central tendency of data. Requirements of good measure b) Locationalaverages: Median, Mode, and Partition Values: Quartiles, Deciles, and Percentiles. c)Mathematical averages Arithmetic mean (Simple, weighted mean, combined mean), Geometric mean, Harmonic mean, d)Empirical relation between mean, median and mode e)Merits and demerits of using different measures &their applicability	**15 Lectures**
Unit III - Measures of Dispersion, Skewness & Kurtosis a) Concept of dispersion. Requirements of good measure. b) Absolute and Relative measures of dispersion: Range, Quartile Deviation, Mean absolute deviation, Standard deviation. c) Variance and Combined variance, raw moments and central moments and relations between them. Their properties d) Concept of Skewness and Kurtosis: Measures of Skewness: Karl Pearson's, Bowley's and Coefficient of skewness based on moments.Measure of Kurtosis, e) Box Plot	**15 Lectures**

COURSE USST201: DESCRIPTIVE STATISTICS-1I

UNIT – I:Correlation and regression analysis a) Scatter Diagram, Product moment correlation coefficient and its properties. Spearman's Rank correlation.(With and without ties) b) Concept of linear regression. Principle of least squares. Fitting a straight line by method of least squares. c) Relation between regression coefficients and correlation coefficient. d) Fitting of curves reducible to linear form by transformation. Concept and use of coefficient of determination (R^2). **e)** Fitting a quadratic curve by method of least squares.	**15 Lectures**
UNIT – II : Time Series Definition of time series .Its component. Models of time series. Estimation of trend by: i) Freehand curve method ii) method of semi average iii)Method of Moving average iv) Method of least squares(linear trend only) Estimation of seasonal component by i) method of simple average ii) Ratio to moving average iii)Ratio to trend method .	**15 Lectures**
Unit III - Index Numbers a) Index numbers as comparative tool. Stages in the construction of Price Index Numbers. b) Measures of Simple and Composite Index Numbers. Laspeyre's, Paasche's, Marshal-Edgeworth's, Dobisch & Bowley's and Fisher's Index Numbers formula. c) Quantity Index Numbers and Value Index Numbers Time reversal test,Factor reversal test, Circular test. d) Fixed base Index Numbers, Chain base Index Numbers.Base shifting, splicing and deflating. e) Cost of Living Index Number.Concept of Real Income based on Wholesale Price Index Number	**15 Lectures**

SEMESTER I : Practicals

1. **Tabulation**
2. **Attributes**
3. **Classification of Data**
4. **Diagrammatic representation.**
5. **Measures of central tendency**
6. **Measures of dispersion**
7. **Practical using Excel and R**

   i)Classification of Data and Diagrammatic representation.

   ii)Measures of central tendency

   iii)Measures of dispersion

SEMESTER II: Practicals

1. **Correlation analysis**
2. **Regression analysis**
3. **Fitting of curve**
4. **Time series**
5. **Index number-I**
6. **Index number-II**
7. **Practical using Excel and R**

   i) Correlation analysis

   ii) Regression analysis

   iii) Fitting of curve

Proposed syllabus F.Y.B.Sc

SEMESTER I

COURSE USST102

STATISTICAL METHODS-1

UNIT – I

Elementary Probability Theory :

Trial, random experiment, sample point and sample space.

Definition of an event. Operation of events, mutually exclusive and exhaustive events.

Classical (Mathematical) and Empirical definitions of Probability and their properties.

Theorems on Addition and Multiplication of probabilities.

Independence of events, pairwise and mutual independence for three event Conditional probability, Bayes theorem and its applications.

UNIT – II

Concept of Discrete random variable and properties of its probability distribution :

Random variable. Definition and properties of probability distribution and cumulative distribution function of discrete random variable.

Raw and Central moments(definition only) and their relationship.(upto order four).

Concepts of Skewness and Kurtosis and their uses.

Expectation of a random variable. Theorems on Expectation & Variance.

Joint probability mass function of two discrete random variables.

Marginal and conditional distributions. Theorems on Expectation &Variance,

Covariance and Coefficient of Correlation. Independence of two random variables.

UNIT – III

Some Standard Discrete Distributions:

Discrete Uniform, Binomial and Poisson distributions and derivation of their mean and variance.

Recurrence relation for probabilities of Binomial and Poisson distributions .Poisson approximation to Binomial distribution .Hyper geometric distribution, Binomial approximation to hyper geometric distribution.

SEMESTER II

COURSE USST202

STATISTICAL METHODS-2

UNIT – IV

Continuous random variable :

Concept of Continuous random variable and properties of its

probability distribution

Probability density function and cumulative distribution function.

Their graphical representation.

Expectation of a random variable and its properties. Measures of location, dispersion, skewness

and kurtosis. Raw and central moments (simple illustrations).

UNIT – V

Some Standard Continuous Distributions :

Uniform, Exponential (location scale parameter) , memory less property of exponential distribution and Normal distribution.

Derivations of mean, median and variance for Uniform and Exponential distributions. Properties

of Normal distribution (without proof). Normal approximation to Binomial and Poisson

distribution (statement only). Properties of Normal curve. Use of normal tables.

UNIT – VI

Elementary topics on Estimation and Testing of hypothesis:

Sample from a distribution :

Concept of a statistic, estimate and its sampling distribution. Parameter and it's estimator.

Concept of bias and standard error of an estimator.

Central Limit theorem (statement only).

Sampling distribution of sample mean and sample proportion. (For large sample only)

Standard errors of sample mean and sample proportion.

Point and Interval estimate of single mean, single proportion from sample of large size.

Statistical tests :

Concept of hypothesis

Null and alternate hypothesis,

Types of errors, Critical region, Level of significance.

Large sample tests (using central limit theorem, if necessary)

For testing specified value of population mean

For testing specified value in difference of two means

For testing specified value of population proportion

For testing specified value of difference of population proportion

(Development of critical region is not expected.)

Use of central limit theorem**.**

PRACTICALS IN STATISTICS

Distribution of the topics for the practicals

SEMESTER I Course code USSTP1

Sr.No	(B)
1	Probability.
2	Discrete Random Variables
3	Bivariate Probability Distributions.
4	Binomial distribution
5	Poisson distribution
6	Hyper geometric distribution
7	Practicals Using R Binomial, Poisson, Hyper geometric distribution

SEMESTER II

Course code USSTP2

Sr.No	(B)
1	Continuous Random Variables
2	Uniform, Exponential and Normal Distributions
3	Applications of central limit theorem and normal approximation
4	Testing of Hypothesis
5	Large Sample Tests
6	2,3,4,5, Practicals Using R

REFERENCES .

1 Medhi J. : Statistical Methods, An Introductory Text, Second Edition, New Age International Ltd.

2 Agarwal B.L. : Basic Statistics, New Age International Ltd.

3 Spiegel M.R. : Theory and Problems of Statistics, Schaum' s Publications series. Tata McGraw-Hill.

4 Kothari C.R. : Research Methodology, Wiley Eastern Limited.

5 David S. : Elementary Probability, Cambridge University Press.

6 Hoel P.G. : Introduction to Mathematical Statistics, Asia Publishing House.

7 Hogg R.V. and Tannis E.P. : Probability and Statistical Inference. McMillan Publishing Co. Inc.

8 Pitan Jim : Probability, Narosa Publishing House.

9 Goon A.M., Gupta M.K., Dasgupta B. : Fundamentals of Statistics, Volume II : The World Press Private Limited, Calcutta.

****

UNIVERSITY OF MUMBAI

Syllabus for the S. Y. B.Sc.
Program: B.Sc.
Course : STATISTICS

(Credit Based Semester and Grading System with effect from the academic year 2017–2018)

S.Y.B.Sc. STATISTICS Syllabus
For Credit Based and Grading System
To be implemented from the Academic year 2017-2018
SEMESTER III

Course Code	UNIT	TOPICS	Credits	L / Week
USST301	I	Univariate Random Variables. (Discrete and Continuous)	2	1
	II	Standard Discrete Probability Distributions.		1
	III	Bivariate Probability Distributions.		1
USST302	I	Concepts of Sampling and Simple Random Sampling.	2	1
	II	Stratified Sampling.		1
	III	Ratio and Regression Estimation.		1
USSTP3				6
USSTP3(A)	Practicals based on USST301		1	3
USSTP3(B)	Practicals based on USST302		1	3

SEMESTER IV

Course Code	UNIT	TOPICS	Credits	L / Week
USST401	I	Standard Continuous Probability Distributions.	2	1
	II	Normal Distribution.		1
	III	Exact Sampling Distributions.		1
USST402	I	Analysis of Variance.	2	1
	II	Design Of Experiments, Completely Randomized design & Randomized Block Design.		1
	III	Latin Square Design & Factorial Experiments.		1
USSTP4				6
USSTP4(A)	Practicals based on USST401		1	3
USSTP4(B)	Practicals based on USST402		1	3

Course Code	Title	Credits
USST301	**PROBABILITY DISTRIBUTIONS**	**2 Credits (45 lectures)**
Unit I	**Univariate Random Variables (Discrete and Continuous):**	15 Lectures

Moment Generating Function(M.G.F.):

Definition

Properties:

- Effect of change of origin and scale,

- M.G.F of sum of two independent random variables X and Y ,

- Extension of this property for n independent random variables and for n i.i.d. random variables.

All above properties with proof,

- Uniqueness Property without proof.

- Raw moments using M.G.F: using expansion method and using derivative method.

Cumulant generating Function(C.G.F.):

Definition

Properties:

- Effect of change and origin and scale ,

- Additive Property of C.G.F. and cumulants

Both properties with proof.

Obtaining Cumulants using C.G.F.

Derivation of relationship between moments and cumulants upto order four.

Characteristic Function:

Definition and properties (without Proof)

Examples of obtaining raw moments and central moments up

to order four using M.G.F. and C.G.F. for continuous and

discrete distributions .

Degenerate distribution(One point distribution) P(X=c) =1

Mean, Variance, Use of Degenerate distribution . Discrete Uniform distribution. Mean, Variance, coefficient of skewness using m.g.f., Bernoulli distribution. Mean, Variance, coefficient of skewness using m.g.f. **Binomial distribution :** Mean, Variance, Measures of skewness and Kurtosis based on moments using M.G.F.and C.G.F. , Nature of probability curve, Mode, Additive property , If X follows Binomial, then to find distribution of n-X. Recurrence relation for moments with proof: $\mu'_{r+1} = npq\ \mu'_r + pq\ \frac{d}{dp}\ \mu'r$ $\mu_{r+1} = pq\ [\ nr\ \mu_{r-1} + \frac{d}{dp}\ \mu r\ ]$ Relation between Bernoulli and Binomial using m.g.f. Transformation of random Variable (Univariate) : examples based on it.		
Unit II	**Standard Discrete Probability Distributions**	15 Lectures
Poisson distribution Mean, Variance, Measures of skewness and Kurtosis based on moments using M.G.F.and C.G.F. , Nature of probability distribution with change in the values of parameters, Mode, Additive property. Recurrence relation for moments with proof for μ'_{r+1} ,μ_{r+1} If X and Y are two independent Poisson variables Conditional distribution of X given X+Y with proof Poisson distribution as limiting distribution of Binomial (with proof) Real life examples of Binomial, Poisson distribution. **Geometric Distribution** Definition in terms of No. of failures and No. of trials. Mean, Variance, M.G.F., Mean and Variance using M.G.F., C.G.F., Mean and Variance,μ_3,μ_4 using C.G.F., Coefficients of skewness and		

Kurtosis and nature of probability distribution. Lack of Memory property with proof. If X and Y are two i.i.d. Geometric variables; Conditional distribution of X given X+Y with proof Distribution of sum of k i.i.d. Geometric variables. **Negative Binomial Distribution** Definition, Mean, Variance, M.G.F., Mean and Variance using M.G.F., C.G.F., Recurrence relation for central moments, Mean, Variance,μ_3,μ_4 using C.G.F., Coefficients of skewness and Kurtosis and nature of probability distribution. Lack of Memory property with proof. Recurrence relation for probabilities, Fitting of distribution. Limiting distribution of Negative Binomial distribution (with proof) **Hyper geometric distribution** Definition,Mean,Variance,Limiting distribution of Hyper geometric distribution (with proof) If X and Y are two independent Binomial variables Conditional distribution of X given X+Y (with proof) **Truncated distribution** Definition Truncated Binomial and Truncated Poisson Distribution: (truncated at 0) Probability mass function, mean and variance. Real life situations of Geometric, Negative Binomial, Hypergeometric distributions		
Unit III	**Bivariate Probability Distributions**	**15 Lectures**
Two dimensional Discrete random variables -Joint Probability mass function and its properties -Distribution function of (X,Y) and its properties -Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables -Marginal and conditional probability distributions		

-Conditional expectation, conditional variance **Continuous bivariate random variables** -Joint Probability density function and its properties -Distribution function of (X,Y) and its properties -Definition of raw and central moments, covariance, correlation coefficient, Independence and correlation between two variables -Marginal and conditional probability distributions -Conditional expectation, conditional variance - Regression Function. Transformation of Random Variables and Jacobian of transformation with illustrations.	

REFERENCES:

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

Course Code	Title	Credits
USST302	**THEORY OF SAMPLING**	**2 Credits (45 lectures)**
Unit I : Concepts: Population, Population unit, Sample, Sample unit, Parameter, Statistic,Estimator, Bias, Unbi Mean square error & Standard error.Census survey, Sample Survey. Steps in conducting sample survey with examples on designing appropriate Questionnaire. Concepts of S and Non-sampling errors. NSSO, CSO and their functions.Concepts and methods of Pr and Non-Probability Sampling. **Simple Random Sampling:** (SRS). 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). 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 and Neyman allocation.		15 Lectures
Unit III : **a. 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

b. Introduction to Systematic sampling, Cluster sampling & Two Stage sampling with suitable illustrations.	

REFERENCES:

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

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-III

COURSE CODE USSTP3

Sr. No	Semester III .Course USSTP3(A)
1	Moment Generating Function, Moments.
2	Cumulant generating Function, Cumulants, Characteristic function.
3	Standard Discrete Distributions.
4	Fitting Standard Discrete Distributions.
5	Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation.
6	Transformation of discrete & continuous random variables.

Sr. No	Semester III .Course USSTP3(B)
1	Designing of Questionnaire.
2	Simple Random Sampling for Variables.
3	Simple Random Sampling for Attributes.
4	Estimation of Sample Size in Simple Random Sampling.
5	Stratified Random Sampling.
6	Ratio Estimation.
7	Regression Estimation.

USST 303 is a new paper for any student of S.Y.B.Sc. Student must have passed 12th standard with Mathematics. If not then He/She has to complete the required bridge course.

Course Code	Title	Credits
USST303	**OPERATIONS RESEARCH 1**	**2 Credits (45 lectures)**
Unit I : Linear Programming Problem (L.P.P.) : Mathematical Formulation: Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. Graphical Solution for problems with two variables. Simplex method of solving problems with two or more variables. Big M method. Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.		**15 Lectures**
Unit II : Transportation Problem: Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization type.		**15 Lectures**
Unit III :Assignment Problem: Concept. Mathematical Formulation Solution by: Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type. Travelling Salesman Problem **Sequencing :** Processing n Jobs through 2 and 3 Machines & 2 Jobs through m Machines.		**15 Lectures**

REFERENCES

1. Operations Research: Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons.
2. Schaum Series book in O.R. Richard Broson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
3. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
4. Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
5. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.
6. Operations Research: S.D.Sharma.11th edition, Kedar Nath Ram Nath & Company.
7. Operations Research: H. A.Taha.6th edition, Prentice Hall of India.
8. Quantitative Techniques For Managerial Decisions: J.K.Sharma , (2001), MacMillan India Ltd.

PRACTICALS BASED ON USST 303

COURSE CODE USSTP3(C)

Practical Number	Title of Practical
01	Formulation and Graphical Solution of L.P.P.
02	Simplex Method
03	Duality
04	Transportation Problems
05	Assignment Problems
06	Sequencing Problems
07	Problems solving using TORA

SEMESTER IV

Course Code	Title	Credits
USST401	**PROBABILITY AND SAMPLING DISTRIBUTIONS**	**2 Credits (45 lectures)**
Unit I	**Standard Continuous Probability Distributions**	15 Lectures

Rectangular or Continuous Uniform over (a,b) Mean, Median Standard deviation,C.D.F.M.G.F., Mean ,variance,μ_3 using M.G.F., skewness of distribution.

For X following U (0,1), distribution of i) $\frac{X}{1+X}$, ii) $\frac{X}{1-X}$

Triangular distribution

Symmetric and asymmetric over(a, b) with peak at c

-M.G.F. Mean ,Variance , d.f. Median.

Exponential Distribution

Definition, M.G.F.,C.G.F. raw moments and central moments up to order four using M.G.F..and C.G.F.

- Measures of Skewness and Kurtosis ,Nature of Probability curve

- Median and Quartiles and Percentiles

-Forgetfulness Property with proof and examples based on it.

-Distribution of $X_{(1)}$,first order statistic -Distribution of ratio of two i.i.d. Exponential random variables. -Distribution of - $\frac{1}{\lambda}$ ln(1-X) ,if X follows Uniform (0,1). -Distribution of X+Y and $\frac{X}{X+Y}$,for two independent Exponential variables X and Y with mean1.(All with proof.) **Cauchy (with location and scale parameter)** -Properties with proof. Distribution of 1/ x. c.d.f. and percentiles. **Gamma (with Scale and shape parameter)** Expression for r th raw moment Mean, variance, Mode & Standard deviation. M.G.F., Additive property, C.G.F.. raw moments and central moments up to order four using M.G.F.. and C.G.F. Coefficients of skewness and Kurtosis and nature of probability curve. Distribution of sum of independent Exponential random variables. **Beta Distribution: Type I & Type II** Expression for r th raw moment, Mean, Mode and Standard deviation, H.M. If a r.v.X follows Beta of type 1, distribution of 1- X If a r.v. X follows Beta of type 2, distribution of i) $\frac{1}{1+X}$, ii)$\frac{X}{1+X}$ With proof. For two independent Gamma variables X and Y with parameters m and n respectively, distribution of U = $\frac{X}{Y}$ and V= $\frac{X}{X+Y}$ with proof.		
Unit II	**Normal Distribution**	15 lectures
Definition, Derivation of Mean, Median, Mode, Standard deviation, M.G.F. , C,G,F., Moments & Cumulants (up to fourth order). skewness & kurtosis, Nature of Normal curve, Mean absolute deviation. Properties of Normal Distribution. Expression for even order central moments and to show that odd order central moments are zero. Percentiles.		

Distribution of Standard normal variable, Percentiles.

Distribution of linear function of independent Normal variables

(i).aX, (ii). X+b, (iii). aX+bY in particular X+Y and X-Y, (iv) $\sum_{i=1}^{P} a_i x_i$ (all with proof.)

Fitting of Normal Distribution.

Central Limit theorem for i.i.d. random variables.(with proof)

Log Normal Distribution: Derivation of mean & variance.

Mode, Median and relation between them.

Distribution of product of n log normal random variables.

Unit III	**Exact Sampling Distributions**	15 lectures

Chi-Square Distribution:

Derivation of p.d.f. , Concept of degrees of freedom. Mean, Mode & Standard deviation. M.G.F.,C.G.F., Measures of skewness and Kurtosis, Additive property

Distribution of ratio of two independent Chi-square variables

Distribution of $\frac{X}{X+Y}$ if X and Y are two independent Chi-square variables

(All with proof)

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 (with proof).

Applications of Chi-Square:

Development of decision criterion with test procedures of

(i) Test of significance for specified value of variance of a Normal population

(ii) Test for goodness of fit,

Test Procedure for independence of attributes.

(i) r × c contingency table,
(ii) 2×2 contingency table, Derivation of test statistic, Yates' correction with proof

Derivation of Confidence interval for the variance of a Normal population when

(i) mean is known, ,
(ii) mean is unknown.

Student's t-distribution:

Derivation of p.d.f. **,** Mean, Median, Mean Deviation & Standard deviation. M.G.F., C.G.F. , Measures of skewness and Kurtosis and Additive property

Limiting distribution of t distribution with proof.

Applications of t:

Development of decision criterion with test procedure of Test of significance for specified value of mean of Normal population.

Test procedure of test of significance for difference between means of

(i) two independent Normal populations with equal variances

(ii) Dependent samples (Paired t test)

Derivation of Confidence intervals for

(i) Mean of Normal population,
(ii) difference between means of two independent Normal populations having the same variance

Snedecor's F-distribution:

Derivation of p.d.f. **,** Expression for r^{th} raw moment, Mean, variance, Mode & Standard deviation

Distribution of Reciprocal of F variable with proof.

Applications of F:

Test procedure for testing equality of variances of two independent Normal populations

i. Mean is known
ii. Mean is unknown

Derivation of confidence interval for ratio of variances of two independent Normal populations.

REFERENCES:

1. Introduction to the theory of statistics: A M Mood, F.A. Graybill, D C Boyes; Third Edition; McGraw-Hill Book Company.
2. Introduction to Mathematical Statistics: R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.
3. Probability and Statistical Inference: R.V.Hogg, E. A.Tannis, Third Edition; Collier McMillan Publishers.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Introduction to Mathematical Statistics: P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.
6. Fundamentals of Mathematical Statistics: S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.
7. Mathematical Statistics: J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.

8. Statistical Methods- An Introductory Text: J. Medhi; Second edition; Wiley Eastern Ltd.
9. An Outline of Statistical Theory Vol. 1: A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; The World Press Pvt. Ltd.

Course Code	Title	Credits
USST402	**ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS**	**2 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 CRD, RBD & LSD.		15 Lectures

Factorial Experiments: Definition, Purpose & Advantages. 2^2, 2^3 Experiments. Calculation of Main & interaction Effects. Definition of contrast and orthogonal contrast, Yates' method. Analysis of 2^2 & 2^3 factorial Experiments.	

REFERENCES

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

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-IV
COURSE CODE USSTP4

Sr. No	Semester IV. Course USSTP4(A)
1	Standard Continuous distributions.
2	Normal Distribution.
3	Central Limit Theorem.
4	Chi Square distribution.
5	t distribution.
6	F distribution.

Sr. No	Semester IV .Course USSTP4(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	Missing Observations in CRD, RBD & LSD.
7	Factorial Experiments.

USST 403 is a new paper for any student of S.Y.B.Sc. Student must have passed 12th standard with mathematics. If not then He/She has to complete the required bridge course.

Course Code	Title	Credits
USST403	**Operations Research - 2**	**2 Credits (45 lectures)**
Unit I : CPM and PERT: Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Network Diagram. Slack time and Float times. Determination of Critical path. Probability consideration in project scheduling. Project cost analysis. Updating.		**15 Lectures**
Unit II : GAME THEORY Definitions of Two persons 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 (2×2) game. Graphical solution of (2×n) and (m×2) games, Reduction of game theory to LPP		**15 Lectures**
Unit III : DECISION THEORY Decision making under uncertainty: Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwitz 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.		**15 Lectures**

Sr. No	Semester IV .Course USSTP4(C)
1	CPM-PERT : Construction of Network.
2	Finding Critical Path. Computing Probability of Project completion.
3	Project cost analysis.
4	Updating.
5	Game Theory 1
6	Game Theory 2
7	Decision Theory-1: Decisions Under Uncertainty
8	Decision Theory-2 : Decisions Under Risk
9	Decision Theory-3 : Decision Tree analysis.

REFERENCES

1. PERT and CPM, Principles and Applications: Srinath. 2nd edition, East-West Press Pvt. Ltd.
2. Quantitative Techniques For Managerial Decisions: J.K.Sharma, (2001), MacMillan India Ltd.
3. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.

4. Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.
5. Operations Research: Kantiswaroop and Manmohan, Gupta. 12thEdition; S Chand & Sons.
6. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
7. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
8. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman,(1959), John Wiley & Sons.
9. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
10. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
11. Bannerjee B. : Operation Research Techniques for Management, First edition, Business Books

Semester End Examination

Theory: At the end of the semester, examination of three (3) hours duration and hundred (100) 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*** will be as follows:
Total number of questions five each of twenty marks.
Question one based on all units. Ten sub-questions of two marks each.
Question two, three, four are based on unit I, unit II and unit III respectively.
Question five based on all units: solve two out of three ten marks each.

Practicals: At the end of the semester, examination of two hours duration and 40 marks shall be held for **each course**. Five marks for journal and Five marks for VIVA. (40+10=50)

Pattern of **Practical question** paper at the end of the semester for **each course**:
There shall be Four questions of ten marks each. Students should attempt all questions.
Question 1 based on Unit 1, Question 2 based on Unit II, Question 3 based on Unit III, Question 4 based on all Three Units combined.
Student should attempt **any two** sub questions out of **three** in each question.

Workload

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

****

UNIVERSITY OF MUMBAI
No. UG/51 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Humanities and Sci. & Tech. Faculty is invited to this office Circular No. UG/107 of 2010, dated 29th May, 2010 and Circular No. UG/108 of 2010 dated 28th May, 2010 relating to syllabus of the B.A./B.Sc. degree course.

They are hereby informed that the recommendations made by the Board of Studies in Statistics at its meeting held on 3rd May, 2018 have been accepted by the Academic Council at its meeting held on 5th May, 2018 **vide** item No. 4.69 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.Y.B.A./B.Sc. in Statistics (Sem - V & VI), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
26th June, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Humanities and Sci. & Tech. Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.69/05/05/2018

****

No. UG/ 51 -A of 2018 MUMBAI-400 032 26th June, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Humanities and Science & Technology,
2) The Chairman, Board of Studies in Statistics,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

UNIVERSITY OF MUMBAI

Syllabus for the T.Y.B.Sc.
Programme: B.Sc.

Sem. V & Sem. VI

Course: STATISTICS

(As per Credit Based Choice System
with effect from the academic year 2018–2019)

T. Y. B. Sc. STATISTICS SYLLABUS

CREDIT BASED AND CHOICE SYSTEM

TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2018-19

SEMESTER V

Theory

Course	UNIT	TOPICS	Credits	L ectures
USST501	I	PROBABILITY	2.5	15
	II	INEQUALITIES AND LAW OF LARGE NUMBERS		15
	III	JOINT MOMENT GENERATING FUNCTION, TRINOMIAL AND MULTINOMIAL DISTRIBUTION		15
	IV	ORDER STATISTICS		15
Course	**UNIT**	**TOPICS**	**Credits**	**L ectures**
USST502	I	POINT ESTIMATION AND PROPERTIES OF ESTIMATORS	2.5	15
	II	METHODS OF POINT ESTIMATION		15
	III	BAYESIAN ESTIMATION METHOD & INTERVAL ESTIMATION		15
	IV	INTRODUCTION TO LINEAR MODELS		15
Course	**UNIT**	**TOPICS**	**Credits**	**L ectures**
USST501	I	EPIDEMIC MODELS	2.5	15
	II	BIOASSAYS		15
	III	CLINICAL TRIALS		15
	IV	CLINICAL TRIALS and BIOEQUIVALENCE		15

Course	UNIT	TOPICS	Credits	L ectures
USST504A (Elective)	I	FUNDAMENTALS OF R	2.5	15
	II	SIMPLE LINEAR REGRESSION MODEL		15
	III	MULTIPLE LINEAR REGRESSION MODEL		15
	IV	VALIDITY OF ASSUMPTIONS		15
Course	**UNIT**	**TOPICS**	**Credits**	**L ectures**
USST504B (Elective)	I	INTRODUCTION	2.5	15
	II	NUMPY, PANDAS AND DATA EXPLORATION		15
	III	DESCRIPTIVE STATISTICS AND STATISTICAL METHODS		15
	IV	INFERENTIAL STATISTICS		15

Course	Practicals	Credits	Lectures per week
USSTP05	Practicals of course USST501+USST502	3	8
USSTP06	Practicals of course USST503+USST504	3	8

Course Code	Title	Credits
USST501	**PROBABILITY AND DISTRIBUTION THEORY**	**2.5 Credits (60 Lectures)**
Unit I : PROBABILITY (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) Addition Theorem for (a) two (b) three events (iv) Conditional Probability: Multiplication Theorem for two, three events. (v) Bayes' theorem. (vi) Theorems on Probability of realization of : (a) At least one (b) Exactly m (c) At least m of N events A_1, A_2, $A_3 \ldots A_N$. Classical occupancy problems, Matching and Guessing problems. Problems based on them.		**15 Lectures**
Unit II : INEQUALITIES AND LAW OF LARGE NUMBERS (i) Markov Inequality (ii) Tchebyshev's Inequality (iii) Boole's Inequality (iv) Cauchy Schwartz's Inequality (v) Weak law of large numbers. (Ref.9,10)		**15 Lectures**

Unit III: JOINT MOMENT GENERATING FUNCTION, TRINOMAIL DISTRIBUTION AND MULTINOMIAL DISTRIBUTION (i) Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Bivariate MGF. **(ii) Trinomial distribution** Definition of joint probability distribution of (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 (X, Y). Distribution of the Sum X+Y Extension to Multinomial distribution with parameters (n, p1, p2,…pk-1) where p1+ p2,+…pk-1+ pk = 1. Expression for joint MGF. Derivation of: joint probability distribution of (Xi, Xj). Conditional probability distribution of Xi	**15 Lectures**
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 functions of all n ordered statistics. (e) Distribution of Maximum observation (n^{th} order statistic) and Minimum observation (first order statistic) in case of uniform and Exponential distribution . (f) Probability density function of the difference between r^{th} and s^{th} order statistic (r<s) in case of uniform and Exponential distribution (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. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
3. Mood A. M., Graybill F. A., Boes 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 & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Biswas S.: Topics in Statistical Methodology, First edition, Wiley Eastern Ltd.
7. Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
8. Chandra T.K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
9. S.C. Gupta and V.K.Kapoor : Fundamental of Mathematical Statistics,Sultan Chand and Sons
10. V K Rohatgi: An Introduction to probability and Mathematical Statistics,

Course Code	Title	Credits
USST502	**THEORY OF ESTIMATION**	**2.5 Credits (60 Lectures)**

Unit I : POINT ESTIMATION AND PROPERTIES OF ESTIMATORS — **15 Lectures**

- **Notion of a Parameter and Parameter Space.**
- **Problem of Point estimation.**
- **Definitions : Statistic, Estimator and Estimate.**
- **Properties of a good estimator** :

1. Unbiasedness **:**Definition of an unbiased estimator, Illustrations and examples.
   Proofs of the following results:

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

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

2. Consistency**:**Definition of Consistency.
Sufficient condition for consistency , proof & Illustrations

3. Sufficiency **:**Concept and Definition of sufficient statistic. Neyman's Factorization theorem (without proof).Exponential family of probability distributions and sufficient statistics.

4. Relative efficiencyof an estimator & illustrative examples.

• **Minimum variance unbiased estimator(MVUE) and Cramer Rao Inequality:** 1.Definition of MVUE 2. Uniqueness property of MVUE (proof). 3. Fisher's information function 4.Regularity conditions. 5. Statement and proof of Cramer-Rao inequality. 6. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. 7. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE. Ref. 1,3,8	
UNIT II : METHODS OF POINT ESTIMATION • **Method of Maximum Likelihood Estimation (M.L.E.) :** **1.** Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. **2.** Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). **3**. Properties of MLE (without proof). • **Method of Moments :** 1. Derivation of Moment estimators for standard distributions (case of one and two unknown parameters) • Illustrations of situations where MLE and Moment Estimators are distinct and their comparison using Mean Square error. • **Method of Minimum Chi-square and Modified Minimum Chi-Square** Ref: 1,2,3	**15 Lectures**

UNIT III: BAYESIAN ESTIMATION METHOD & INTERVAL ESTIMATION • **Bayes Estimation:** 1. Prior distribution, Posterior distribution 2. Loss function, Risk function 3. Types of Loss function: Squared error Loss function (SELF), Absolute error Loss function (AELF) 4. Bayes' risk. 5.Bayes' method of finding Point estimator (assuming SELF) **Examples** : (i) Binomial- Beta (ii) Poisson- Gamma (iii) Gamma-Gamma (iv) Normal-Normal • **Interval Estimation:** 1. Concept of confidence interval & confidence limits. 2. Definition of Pivotal quantity and its use in obtaining confidence limits. 3. Derivation of 100(1-α) % equal tailed confidence interval for : (a)The population mean : $\mu, \mu_1 - \mu_2$ (population variance known/ unknown) (b) the population variance: $\sigma^2, \frac{\sigma_1^2}{\sigma_2^2}$(Normal distribution). Confidence interval for the parameters of Binomial, Poisson and Exponential distributions. Ref. 1,2,3	**15 Lectures**
UNIT IV:INTRODUCTION TO LINEAR MODELS • **Explanation of General Linear Model of full rank with assumptions.** **Model:** $\mathbf{Y} = \mathbf{X}\beta + \underline{\mathbf{e}}$ **where** $\underline{\mathbf{e}} \sim \mathbf{N}(\mathbf{0}, \sigma^2\mathbf{I})$ • **Derivation of** : 1) Least squares estimator of $\underline{\beta}$ 2) $E(\hat{\beta})$ 3) $V(\hat{\beta})$	**15 Lectures**

• **GuassMarkoff theorem for full rank Model: $Y = X\beta + e$.** • **Derivation of :** 1) $E(l'\tilde{\beta})$ 2) $V(l'\tilde{\beta})$. • **Confidence interval for $l'\beta$ when σ^2 is known.** • **Confidence interval of $\hat{\beta}$ when σ^2 is known.** Ref. 9,10.	

Reference books:

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. AroraSanjay and BansiLal : New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi,5(1989)

9. A.M.Kshirsagar; Linear Models

10. F.A. Graybill; An Introduction to Linear Models

2Course Code	Title	Credits
USST503	**BIOSTATISTICS**	**2.5 Credits (60 lectures)**
Unit I : EPIDEMIC MODELS (i) The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for 'a' introductions), 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)		**15 Lectures**
Unit II : BIOASSAYS (i) Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. (ii) Indirect assays. Dose-response relationship. Conditions 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. (iii)Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis. (Ref.2, 3)		**15 Lectures**
Unit III : CLINICAL TRIALS : Introduction to clinical trials : The need and ethics of clinical trials. Common terminology used in clinical trials. Over view of phases (I-IV). Introduction to ICH E9 guidelines, 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		**15 Lectures**

Trial. Inclusion/Exclusion Criteria. Sample size estimation. (Ref. 4, 5, 6, 7, 8)	
Unit IV : CLINICAL TRIALS and BIOEQUIVALENCE : Statistical tools : Analysis of parallel Design using Analysis of Variance. Concept of odds ratio. Concept of Repeated Measures ANOVA. Survival analysis for estimating Median survival time, Kaplan-Meire approach for survival analysis. BIOEQUIVALENCE : Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (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. 4, 5, 6, 7, 8, 9)	**15 Lectures**

REFERENCES :

1. Bailey N.TJ. : 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 Boltan and Charles Bon : 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.

	Title	Credits
USST504A	**Regression Analysis using R software**	**2.5 Credits (60 lectures)**

Unit I : Fundamentals of R — **15 Lectures**

Introduction to R features of R, installation of R, Starting and ending R session, getting help in R , Value assigning to variables

Basic Operations : +, -, *, ÷, ^, sqrt

Numerical functions : log 10, log , sort, max, unique, range, length, var, prod, sum, summary, dim, sort, five num etc

Data Types : Vector, list, matrices, array and data frame

Variable Type and factor : logical, numeric, integer, complex, character

Data Manipulation : Selecting random N rows, removing duplicate row(s), dropping a variable(s), Renaming variable(s), sub setting data, creating a new variable(s), selecting of random fraction of row(s), appending of row(s) and column(s), simulation of variables.

Data Processing : Data import and export, setting working directory, checking structure of Data :Str(), Class(), Changing type of variable (for eg as.factor, as.numeric)

Data Visualisation using ggplot: Simple bar diagram, subdivided bar diagram, multiple bar diagram pie diagram, Box plot for one and more variables, histogram, frequency polygon, scatter plot

eg plot() (Ref.6, 7, 8, 9,10)	
Unit II : Simple linear regression model Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients for simple, Properties of least square estimators (without proof), Coefficient of determination R^2 and adjusted R^2 , Procedure of testing a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients Data Pre-processing: Detection and treatment of missing value(s)and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R. Weighted Least Square Method, Polynomial Regression Models. (Ref. 1,2,3,4,5)	**15 Lectures**
Unit III : Multiple linear regression model Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2 , Procedure of testing a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R. (Ref. 1,2,3,4,5)	**15 Lectures**
Unit IV : Validity of Assumptions Residual Diagnostics: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots of ,Interpretation output produced by plot command in R and corrective measures such as transformation of response variable, testing normality of data . Autocorrelation: Concept and detection using Durbin Watson Test, Interpretation of output produced by DW-test function in R, Heteroscedasticity: Concept and detection using Breusch –Pagan-Godfrey Test, Interpretation of output produced by bptest function in R, Multicollinearity: Concept and detection using R^2 and t-ratios ii) pairwise correlation between repressors iii) Variance Inflation Factor(VIF), Interpretation of output produced by mctest function in R, Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures, Ridge Regression : Concept and case study using R, (Ref. 1,2,3,4,5)	**15 Lectures**

References:

1) Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
2) Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
3) Neter, J., W., Kutner, M. H. ;Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
4) DamodarGujrati, Sangetha,Basic Econometrics, fourth edition, McGraw Hill Companies.
5) William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.
6) Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London
7) Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition. Narosa Publishing House, New Delhi.
8) Shahababa , B. (2011). Biostatistics with R, Springer, New York
9) Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall /CRC Press, New York
10) Asha Jindal (Ed.)(2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College.

	Title	Credits
USST504B	**Statistical Data Analysis using PYTHON**	**2.5 Credits (60 lectures)**
Unit I : Introduction To PYTHON Software Python Setup Python Arithmetic Basic Data Types Variables Lists Tuples and Strings Dictionaries and sets Ref: 1,2,3		**15 Lectures**
Unit II : Numpy, Pandas and Data Exploration numpy arrays: Creating arrays crating n-dimensional arrays using np.array and array operations(indexing and slicing, transpose, mathematical operations) pandas dataframes: Creating series and dataframes and Operations on series and dataframes Reading and writing data: From and to Excel and CSV files		**15 Lectures**

Control statements: if, if-else, if-elif, while loop, for loop Defining functions: def statement Text data operations: len, upper, lower, slice, replace, contains Frequency Tables Ref: 1,2,3	
Unit III : Descriptive statistics and Statistical Methods Plotting: using "matplotlib"(Histograms, Box plots, Scatter plot, Bar plot, Line plot) Descriptive Statistics: mean, median, mode, min, max, quantile, std, var, skew, kurt, correlation Probability distributions: (using scipy.stats) Simulation from distributions, computations of probabilities, Cumulative probabilities, quantiles and drawing random sample using functions for following distributions: Binomial, Poisson, Hypergeometric, normal, exponential, gamma, Cauchy, Lognormal,Weibull, uniform, laplace ,Graphs of pmf/pdf by varying parameters for above distributions and Fitting of distributions.. Ref: 1,2,3	**15 Lectures**
Unit IV : *Inferential Statistics* Hypothesis testing and T-Tests: (using scipy.stats, math)ttest_1samp, ttest_ind(2 sample test), ttest_rel(paired), Type I and Type II error Chi-square tests: (using scipy.stats) chisquare, chi2 ANOVA: (using scipy.stats) f_oneway Linear regression: from sklearn import linear model and use linearmodel.linearregression function. Ref: 1,2,3	**15 Lectures**

REFERENCES :

1. Python for Data Analysis by O'Reilly Media (Second Edition)

2. How to think like a computer scientist learning with Python by Allen Downey.

3. Python for Data Analysis by Armando Fernandgo

DISRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER V

COURSE CODE USSTPO5 :

Sr. No.	Practical topics from USST501		Sr. No.	Practical topics from USST502
5.1.1	Probability-I		5.2.1	MVUE and MVBUE
5.1.2	Probability-II		5.2.2	Methods of Estimation
5.1.3	Inequalities and WLLN		5.2.3	Baye's Estimaion
5.1.4	Trinomial and Multinomial Distribution		5.2.4	Confidence Interval
5.1.5	Order statistics-I		5.2.5	Linear model
5.1.6	Order statistics-II		5.2.6	Use of R software

COURSE CODE USSTPO6 :

Sr. No.	Practical topics from USST503		Sr. No.	Practical topics from USST504A	Sr. No.	Practical topics from USST504B
5.3.1	Epidemic Models		5.4A.1	Fundamentals of R	5.4B.1	Descriptive statistics
5.3.2	Direct Assays		5.4A.2	Graphs using R	5.4B.2	Correlations and Simple Regression
5.3.3	Parallel Line Assays		5.4A.3	Diagrams using R	5.4B.3	Probability Distributions :Discrete
5.3.4	Quantal Response Assays		5.4A.4	Simple Linear Regression using R	5.4B.4	Probability Distributions :Continuous
5.3.5	Clinical Trials		5.4A.5	Weighted Least Square using R	5.4B.5	Statistical Test: t test Chisquare and F test
5.3.6	Bioequivalance		5.4A.6	Multiple Linear Regression and Ridge Regression using R	5.4B.6	ANOVA

T. Y. B. Sc. STATISTICS SYLLABUS

CREDIT BASED AND CHOICE SYSTEM

TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2018-19

SEMESTER VI

Theory

COURSE	UNIT	TOPICS	CREDITS	LECTURES
USST601	I	BIVARIATE NORMAL DISTRIBUTION	2.5	15
	II	GENERATING FUNCTIONS		15
	III	STOCHASTIC PROCESSES		15
	IV	QUEUING THEORY		15
USST602	I	MOST POWERFUL TESTS	2.5	15
	II	UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS		15
	III	SEQUENTIAL PROBABILITY RATIO TESTS		15
	IV	NON-PARAMETRIC TESTS		15
USST603	I	LINEAR PROGRAMMING PROBLEM	2.5	15
	II	INVENTORY CONTROL		15
	III	REPLACEMENT		15
	IV	SIMULATION AND RELIABILITY		15
USST604A (Elective)	I	MORTALITY TABLES	2.5	15
	II	COMPOUND INTEREST AND ANNUITIES CERTAIN		15
	III	LIFE ANNUITIES		15
	IV	ASSURANCE BENEFITS		15
USST604B (Elective)	I	INTRODUCTION TO BASIC STATISTICS	2.5	15
	II	SIX SIGMA		15
	III	CONTROL CHARTS I		15
	IV	CONTROL CHARTS II		15

Course	Practicals	Credits	Lectures per week
USSTP07	**Practicals of course USST601+USST602**	**3**	**8**
USSTP08	**Practicals of course USST603+USST604**	**3**	**8**

Course Code	Title	Credits
USST601	**DISTRIBUTION THEORY AND STOCHASTIC PROCESSES**	**2.5 Credits (60 lectures)**
Unit I : BIVARIATE NORMAL DISTRIBUTION (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 for ρ. (Ref. 2,3,5,9)		**15 Lectures**
Unit II : 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.1,5)		**15 Lectures**
Unit III : STOCHASTIC PROCESSES 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.1,7,9)		**15 Lectures**
Unit IV : QUEUING THEORY 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)		**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. & Craig A.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 & Kapoor V 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. Medhi J: Stochastic Processes, Second edition, Wiley Eastern Ltd.
8. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
9. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company

Course Code	Title	Credits
USST602	**TESTING OF HYPOTHESIS**	**2.5 Credits (60 lectures)**

Unit I : MOST POWERFUL TESTS — **15 Lectures**

- 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. Randomised test (Ref. 1,2,10)

Unit II :UNIFORMLY MOST POWERFUL& LIKELIHOOD RATIO TESTS — **15 Lectures**

- Definition, Existence and Construction of Uniformly most powerful (UMP) test (Ref. 1,2,10)
- 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 hypothesis) (Ref. 1,2,3,4)

Unit III: SEQUENTIAL PROBABILITY RATIO TESTS — **15 Lectures**

- 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). Graphical/Tabular procedure for carrying out SPRT. Problems based on Bernoulli, Binomial. Poisson, Normal & Exponential distributions. (Ref. 1,6,7,8)

Unit IV: NON-PARAMETRIC TESTS — **15 Lectures**

- 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–Whitney test (v) Run test (vi) Fisher exact test (vii) Kruskal -Wallis test (viii) Friedman test

• Assumptions, justification of the test procedure for small & large samples . (Ref.5,9)	

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 and its applications, Second Edition Wiley Series in Probability and Statistics.
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. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
8. Sanjay Aroraand BansiLal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
9. Sidney Siegal& N John Castellan Jr.:Non parametric test for behavioral sciences, McGraw Hill c-1988
10. A. Mood , F. Graybill& D. Boes:Introduction to the theory of Statistics- McGraw Hill

Course Code	Title	Credits
USST603	**OPERATIONS RESEARCH TECHNIQUES**	**2.5 Credits (60 lectures)**
Unit I : LINEAR PROGRAMMING PROBLEM Two-Phase Simplex Method, Algorithm. Dual Simplex Method, Algorithm. Post Optimality Sensitivity Analysis. Effect on optimal solution to the LPP and improvement in the solution due to (i) Change in cost coefficient, (ii)Change in the element of requirement vector, (iii) Addition/deletion of a variable,(iv) Addition/deletion of a constraint. (All expressions without proof) (Ref. 2, 3)		**15 Lectures**
Unit II : 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, 2, 3)		**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. 3)		**15 Lectures**
Unit IV : SIMULATION AND RELIABILITY Concept and Scope of simulation. Monte Carlo Technique of Simulation.Generation of random numbers using (i) Mid. Square Method and (ii) Multiplicative Congruential Method. Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. Simulation techniques applied to inventory and queueing model. (Ref. 1, 4) RELIABILITY: Concept of reliability, Hazard-rate. Bath tub curve. Failure time distributions : (i) Exponential, (ii) Gamma, (iii) Weibull, (iv)		**15 Lectures**

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. 5,6)

REFERENCES :

1. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
2. Kantiswarup, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
3. Sharma S. D. : Operations Research, Eighth edition, Kedarnath Ramnath & Co.
4. Taha Hamdy A. : Operations Research : Eighth edition, Prentice Hall of India Pvt. Ltd.
5. Barlow R. E. and Prochan Frank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
6. Mann N. R., Schafer R.E., Singapurwalla N. D.: Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.

Course Code	Title	Credits
USST604A	**ACTURIAL SCIENCE**	**2.5 Credits (60 lectures)**
Unit I: MORTALITY TABLES Various mortality functions. Probabilities of living and dying. The force of mortality. Estimation of μx from the mortality table. Central Mortality Rate. 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 when successive instalments form arithmetic progression (iii) annuity with frequency different 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) double endowment assurance (vi) special endowment assurance (vii) deferred temporary assurance. Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans .Natural and 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.

Course Code	Title	Credits
USST604B	**INTRODUCTION TO SIX SIGMA**	**2.5 Credits (60 lectures)**
Unit I : INTRODUCTION TO BASIC STATISTICS Descriptive Statistics, Data Distribution, Skewness, Kurtosis, Box and Whisker plots, Inferential Statistics (Sample, Population, Normal Distribution, CLT theorem, Sampling distribution of mean), Hypothesis testing with Normal and Non-Normal data : [*1 and 2 sample tests, 1 sample variance, One way ANOVA, Mann-Whitney U test, Kruskal-Wallis test, Moods median test, Chi-square test*], Regression analysis, Designed experiments. (Ref. 1,2)		**15 Lectures**
Unit II : SIX SIGMA History and concept, Basic Principles, Goals, six sigma v/s TQM, ISO 9000, Traditional Management, Quality defined, VOC and CTQ, Quality measurement to six sigma, Seven tools of quality and its application: 1) Histogram or Stem and Leaf display. 2) Check sheet. 3) Pareto Chart. 4) Cause and Effect diagram (Fish bone Diagram) 5) Defect concentration diagram. 6) Scatter diagram. 7) Control charts (**Only concept of control chart**), DMAIC with case study, introduction to Lean Six Sigma. (Ref. 3,4,5,6,7,8,9,10)		**15 Lectures**
Unit III : CONTROL CHARTS I Introduction, Chance and assignable causes, Statistical basis of the control chart: Basic principles of control chart (Shewhart control charts), Choice of control limits, Sample size and sampling frequency, Rational subgroups, Analysis of patterns on control charts, Discussion of sensitizing rules for control chart. Introduction to the concept of attribute, Defect. P, np, c and u charts, their uses. p-chart with variable sample size. Operating-Characteristic function, Average run length. Applications of variable control charts.*(In addition problems involving setting up standards for future use is also expected),* Guidelines to implement control charts. *(In addition problems involving setting up standards for future use is also expected)*. Ref. 11,12,13,14,15,16)		**15 Lectures**
Unit IV : CONTROL CHARTS II Control chart for variables variables. X-Bar, R, S [*sample standard deviation*] (Construction, charts based on standard values, Interpretation), Operating-Characteristic function, Average run length. Applications of variable control charts. Introduction to process capability concept, Specification limits, natural		**15 Lectures**

tolerance limits and their comparisons, estimate of percent defectives, Capability ratio and Capability indices(Cp), Capability performance indices Cpk with respect to machine and process interpretation, relationship between i) Cp and Cpk ii) Defective parts per million and Cp (Ref. 11,12,13,14,15,16)	

References:

1. Fundamental of Mathematical Statistics, Gupta and Kapoor.
2. Probability and Random process by T. Veerarajan.
3. Six Sigma For Business Excellence, (2005), Penelope Przekop, McGraw-Hill Six Sigma Handbook, by Pyzdek, McGraw Hill Education; 4 edition (1 July 2017).
4. The Certified Six Sigma Green Belt Handbook, Roderick A. Munro and Govindarajan Ramu , American Society for Quality (ASQ),
5. What Is Design For Six Sigma,(2005), Roland Cavanagh, Robert Neuman, Peter Pande, Tata McGraw-Hill
6. The Six Sigma Way: How GE, Motorola, And Other Top Companies Are Honing Their Performance, (2000), Peter S. Pande, Robert P. Neuman, Roland R. Cavanagh, McGraw-Hill
7. What Is Lean Six Sigma,(2004), Mike George, Dave Rowlands, Bill Kastle, McGraw-Hill
8. Six Sigma Deployment,(2003), Cary W. Adams, Charles E Wilson Jrs, Praveen Gupta, Elsevier Science.
9. Six Sigma For Beginners: Pocket Book (2018), Rajiv Tiwari Kindle Edition
10. Introduction to Statistical Quality Control(2009), Montgomery, Douglas, C ,Sixth Edition, John Wiley & Sons.Inc.:.
11. Statistical Quality Control: E.L.Grant. 2nd edition, McGraw Hill, 1988.
12. Quality Control and Industrial Statistics: Duncan. 3rd edition, D.Taraporewala sons & company.
13. Quality Control: Theory and Applications: Bertrand L. Hansen, (1973),Prentice Hall of IndiaPvt. Ltd..
14. Introduction to Statistical Quality Control(2009), Montgomery, Douglas, C. , Sixth Edition, John Wiley & Sons, Inc.:
15. Quality Control (1976), I.V. Burr, Mardekkar, New York,
16. Fundamentals of Applied Statistics , Gupta and Kapoor

DISRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER VI

COURSE CODE USSTPO7 :

Sr. No.	Practical topics from USST601		Sr. No.	Practical topics from USST602
6.1.1	Bivariate Normal Disribution		6.2.1	Testing of Hypothesis - I
6.1.2	Tests for correlation and Interval estimation		6.2.2	Testing of Hypothesis - II
6.1.3	Generating Function		6.2.3	SPRT
6.1.4	Stochastic Process		6.2.4	Non-parametric Test - I
6.1.5	Queuing Theory - I		6.2.5	Non-parametric Test - II
6.1.6	Queuing Theory - II		6.2.6	Use of R software

COURSE CODE USSTPO8 :

Sr. No.	Practical topics from USST603		Sr. No.	Practical topics from USST604A	Sr. No.	Practical topics from USST604B
6.3.1	L.P.P.		6.4A.1	Mortality table I	6.4B.1	**Descriptive statistics**
6.3.2	Inventory I		6.4A.2	Mortality table II	6.4B.2	**Testing of hypothesis**
6.3.3	Inventory II		6.4A.3	Annuities I	6.4B.3	**Seven Tools of Quality**
6.3.4	Replacement		6.4A.4	Annuities II	6.4B.4	**Attribute control charts**
6.3.5	Simulation		6.4A.5	Life Annuities	6.4B.5	**Variable Control Charts and Capability Analysis**

6.3.6	Reliability		6.4A.6	Assurance benefits	6.4B.6	Practical based on 1,2,3,4,5 using MS-Excel

Semester End Examination:
Theory: At the end of the semester, Theory examination of three hours duration and 100 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 compulsory questions of twenty marks each with internal option.
Question 1 based on Unit I.
Question 2 based on Unit II.
Question 3 based on Unit III.
Question 4 based on Unit IV.
Question 5 based on all Four Units combined.

Semester End Examination Practicals : At the end of the semester, Practical examination of 3 hours duration and 100 marks (80+10*+10**) shall be held for each course as shown below:

Practical Course	Part A	Part B	Duration	Marks out of
USSTP05	Questions from USST501	Questions from USST502	3 hours	80
USSTP06	Questions from USST503	Questions from USST504	3 hours	80
USSTP07	Questions from USST601	Questions from USST602	3 hours	80
USSTP08	Questions from USST603	Questions from USST604	3 hours	80

*: Practical journal 10 marks, **: Viva 10 marks
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 40 marks each. Students to attempt one question from each part.

Guidelines for conducting University examination of Paper on Statistical software at T.Y. B.Sc. Semester V

a. The examination will be conducted in Statistics laboratory on computers.
b. Provision of at least 15 computers with necessary R / Python / MSExcel software installed should be made available by the centre. Battery backup in case of power failure is essential.
c. Duration of examination is one and hal hours.
d. The examination will be conducted batch wise. A batch will consist of at most 15

candidates.

e. The batches examined simultaneously will have same question paper. However there will be separate question paper for each batch in case more (than one) batches are required to be formed.

f. A candidate will solve the question paper given to him/ her on computer and the output of work done by him/her will be evaluated by the examiner.

g. In case of partial power failure proportionate additional time may be given at that centre for the concerned batch.

h. One internal examiner and one external examiner will be appointed for this examination.

Workload Theory: 4 lectures per week per course. Practicals: 4 lecture periods per course per week per batch. All four periods of the practicals shall be conducted in succession together on a single day.

****