

# STATISTICS (CORE)

## CREDIT BREAK UP

Sl. no.	Courses	No. of papers	No. of papers x credit (theory + practical/tutorial)	Total credits
1	Core	14	14x6	84
2	Ability Enhancement compulsory courses(AECC)	2	2x2	4
3	Discipline Specific Elective Papers (DSE)	4	4x6	24
4	Skill Enhancement Elective (SEE)	2	2x2	4
5	Generic Elective (GE) (Physics/Mathematics/Economics/Computer Sciences)	4	4 x 6	24
<b>Total</b>		26		140

## Choice Based Credit System

	<b>CORE COURSE (14)</b>	<b>Ability Enhancement Compulsory Course (AECC) (2)</b>	<b>Skill Enhancement Elective Course (SEEC) (2)</b>	<b>Elective: Discipline Specific DSE (4)</b>	<b>Generic Elective: (GE) (4)</b>
I	Descriptive Statistics(Theory+ Practical)	(English/MIL Communication) /Environmental Science			GE-1
	Calculus				
II	Probability and Prob. Distributions(Theory+ Practical)	Environmental Science/ (English/MIL Communication)			GE-2
	Algebra				
III	Sampling Distributions(Theory+ Practical)		STAT-SEE-1		GE-3
	Survey Sampling & Indian Official Statistics (Theory+ Practical)				
	Mathematical Analysis				
IV	Statistical Inference(Theory+ Practical)		STAT-SEE-2		GE-4
	Linear Models(Theory+ practical)				
	Statistical Quality Control(Theory+ Practical)				

<b>V</b>	Stochastic Processes and Queuing Theory(Theory+ Practical)			STAT-DS E-1	
	Statistical Computing Using C/C++Programming (Theory+ Practical)			STAT-DS E -2	
<b>VI</b>	Design of Experiments (Theory+ Practical)			STAT-DS E-3	
	Multivariate Analysis and Nonparametric Methods (Theory+ Practical)			STAT-DS E -4	

# Under Graduate Course Structure in Statistics (core)

## Detailed structure

<b>SEMESTER I</b>			
<b>Paper Code</b>	<b>COURSE NAME</b>		<b>Credits</b>
STAT-AEC-1	(English/MIL Communication) /Environmental Science	Ability Enhancement Compulsory	2
STAT-C-101	Descriptive Statistics	Core Discipline	4
STAT-C-101 (Pract)	Practical		2
STAT-C-102	Calculus	Core Discipline	5
	Tutorial		1
GE-1	Any one from the list of Generic Electives/interdisciplinary courses from other subjects (Physics/Mathematics/ Economics/Computer Sciences)	Generic Elective/ Interdisciplinary	4 or 5
	Practical /Tutorial		2 or 1
<b>SEMESTER II</b>			
STAT-AEC-2	Environmental Science/(English/MIL Communication)	Ability Enhancement	2
STAT-C-201	Probability and probability distribution	Core Discipline	4
	Practical		2
STAT-C-202	Algebra	Core Discipline	5
	Tutorial		1

<b>GE-2</b>	Any one from the list of Generic Electives/interdisciplinary courses from other subjects (Physics/Mathematics/Economics/Computer Sciences)	Generic Elective/ Interdisciplinary	4 or 5
	Practical/tutorial		2 or 1
<b>SEMESTER-III</b>			
<b>STAT-C-301</b>	Sampling Distribution	Core Discipline	4
	Practical		2
<b>STAT-C-302</b>	Survey Sampling & Indian Official Statistics	Core Discipline	4
	Practical		2
<b>STAT-C-303</b>	Mathematical Analysis	Core Discipline	5
	Tutorial		1
<b>STAT-SEE-1</b>	Statistical Data Analysis using Software Packages (SPSS and other statistical soft ware packages)	Skill Enhancement Elective	2
<b>GE-3</b>	Any one from the list of Generic Electives/interdisciplinary courses from other subjects (Physics/Mathematics/Economics/Computer Sciences)	Generic Elective/ Interdisciplinary	4 or 5
	Practical/Tutorial		2 or 1
<b>SEMESTER-IV</b>			
<b>STAT-C-401</b>	Statistical Inference	Core Discipline	4
	Practical		2
<b>STAT-C-402</b>	Linear Models	Core Discipline	4
	Practical		2
<b>STAT-C-403</b>	Statistical Quality Control	Core Discipline	4
	Practical		2
<b>STAT-SEE-2</b>	Statistical Techniques for Research Methods	Skill Enhancement Elective	2

<b>GE-4</b>	Any one from the list of Generic Electives/interdisciplinary courses from other subjects (Physics/Mathematics/Economics/Computer Sciences)	Generic Elective/ Interdisciplinary	4 or 5
	Practical/Tutorial		2 or 1
<b>SEMESTER-V</b>			
<b>STAT-C-501</b>	Stochastic Processes & Queuing Theory	Core Discipline	4
	Practical/lab work		2
<b>STAT-C-502</b>	Statistical Computing using C/C++ programming	Core Discipline	4
	Practical		2
<b>STAT-DSE-1</b>	Operations Research	Discipline Specific Electives	4
	Practical/lab work		2
<b>STAT-DSE-2</b>	Time Series Analysis	Discipline Specific Electives	4
	Practical		2
<b>SEMESTER-VI</b>			
<b>STAT-C-601</b>	Design of Experiments	Core Discipline	4
	Practical		2
<b>STAT-C-602</b>	Multivariate analysis and Nonparametric Methods	Core discipline	4
	Practical		2
<b>STAT-DSE-3</b>	Demography and Vital Statistics	Discipline Specific Electives	4
	Practical		2
<b>STAT-DSE-4</b>	Project work		6

**SEMESTER-1**  
**STATISTICS (CORE)**  
**STAT-C-101**

***DESCRIPTIVE STATISTICS***

**Credit 6 (Theory 4 + Practical 2)**

**(End semester 50 + Internal Assessment 15)**

**UNIT I** **(Lecture-10, Marks- 12)**

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

**UNIT II** **(Lecture-10, Marks- 14)**

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.

**UNIT III** **(Lecture-10, Marks- 12)**

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

**UNIT IV** **(Lecture-10, Marks- 12)**

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers.

**SUGGESTED READING:**

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

**STAT-C-101 (Practical)**  
**(End semester 30 + Internal Assessment 5)**

**(Lecture-10\*)**

**List of Practical**

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman rank correlation with and without ties.
11. Partial and multiple correlations.
12. Planes of regression and variances of residuals for given simple correlations.
13. Planes of regression and variances of residuals for raw data.
14. Calculate price and quantity index numbers using simple and weighted average of price relatives.
15. To calculate the Chain Base index numbers.
16. To calculate consumer price index number.

**\*1 Lecture= 2 hours**



**SEMESTER-1**  
**STATISTICS (CORE)**  
**STAT-C-102**  
**CALCULUS**

**Credit 6 (End semester 80 + Internal Assessment 20)**

**UNIT I** **(Lecture-15, Marks- 25)**

**Differential Calculus:** Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points.

**UNIT II** **(Lecture-15, Marks- 25)**

**Integral Calculus:** Review of integration and definite integral. Differentiation under integral sign, double integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

**UNIT III** **(Lecture-15, Marks- 15)**

**Differential Equations:** Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. **Higher Order Differential Equations:** Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non-constant coefficients, Reduction of order method, The Cauchy-Euler's equation of order n, Legendre's linear equation.

**UNIT IV:** **(Lecture-15, Marks- 15)**

Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Statement and application of Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

**SUGGESTED READINGS:**

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition -2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt., New Delhi (2nd Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

**SEMESTER-2**  
**STATISTICS (CORE)**  
**STAT-C-201**

***PROBABILITY AND PROBABILITY DISTRIBUTIONS***

**Credit 6**

**UNIT I**

**(Marks: 12, Lecture-10)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

**UNIT II**

**(Marks: 12, Lecture-10)**

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations.

**UNIT III**

**(Marks: 12, Lecture-10)**

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

**UNIT IV**

**(Marks: 14, Lecture-10)**

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.

**SUGGESTED READING:**

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

**PRACTICAL:****(Lecture-10\*)****(End semester 30 + Internal Assessment 5)****List of Practical**

1. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$ .
2. Fitting of binomial distributions for given  $n$  and  $p$ .
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of  $\lambda$ .
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on negative binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.

**\*1 lecture=2 hours****SEMESTER-2****STATISTICS (CORE)**

## **STAT-C-202**

### **ALGEBRA**

#### **Credit 6**

#### **UNIT I**

**(Marks: 20, Lecture-15)**

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem.

#### **UNIT II**

**(Marks: 20, Lecture-15)**

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.

#### **UNIT III**

**(Marks: 20, Lecture-15)**

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for nth order, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations  $AX=B$ , solution sets of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

#### **UNIT IV**

**(Marks: 20, Lecture-15)**

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations). Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their digitalization

#### **SUGGESTED READINGS:**

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines : Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition, 2006.
3. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973

5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Artin M.: Algebra. Prentice Hall of India, 1994.
8. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley G.: Linear Algebra. Narosa Publishing House (Reprint), 2002.
10. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982.

**N.B.: 1 credit= 10 hours of study**

**3<sup>RD</sup> SEMESTER:**

**STAT-C-301 Sampling Distributions**

**CREDIT:6 (Th- 4, Pr- 2)**

**UNIT I**

**(Lecture-10, Marks- 15)**

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof). Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

**UNIT II**

**(Lecture-10, Marks- 10)**

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

**UNIT III**

**(Lecture-10, Marks- 10)**

Exact sampling distribution: Definition and derivation of p.d.f. of  $\chi^2$  with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of  $\chi^2$  distribution. Tests of significance and confidence intervals based on distribution.

**UNIT IV**

**(Lecture-10, Marks- 15)**

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f. nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of  $1/F(n_1, n_2)$ . Relationship between t, F and  $\chi^2$  distributions. Test of significance and confidence Intervals based on t and F distributions. 12L

**SUGGESTED READING:**

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): *An Outline of Statistical Theory*,

Vol. I, 4th Edn. World Press, Kolkata.

2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2<sup>nd</sup>Edn. (Reprint) John Wiley and Sons.

3. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.

4. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4th Edn. John Wiley and Sons.

5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): *Introduction to the Theory of Statistics*, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

**STAT-C-301(Practical)**  
**(End semester 30 + Internal Assessment 5)**  
**List of Practical**

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness of fit.
7. Testing of independence of attributes.
8. Testing based on 2 x2 contingency table without and with Yates' corrections.
9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances

**STAT-C-302 Survey Sampling and Indian Official Statistics**

**CREDIT:6 (Th- 4, Pr- 2)**

**UNIT I**

**(Lecture-10, Marks- 15)**

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

**UNIT II**

**(Lecture-10, Marks- 15)**

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ( $N=n \times k$ ). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

**UNIT III**

**(Lecture-10, Marks- 12)**

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling

**UNIT IV**

**(Lecture-10, Marks- 8)**

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

**SUGGESTED READING:**

1. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of

Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics

3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.

4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.

5. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.

6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.

7. <http://mospi.nic.in/>

### **STAT-C-302(Practical)**

#### **(End semester 30 + Internal Assessment 5)**

##### **List of Practical**

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods  
Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.



**STAT C- 303- Mathematical Analysis****CREDIT: 6****UNIT-I****(Lecture-12L+3T, Marks- 20)**

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Supremum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

**UNIT-II****(Lecture-12L+3T, Marks- 20)**

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence. Indeterminate form, L' Hospital's rule.

**UNIT-III****(Lecture-10L+2T, Marks- 15)**

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder(without proof). Taylor's and Maclaurin's series expansions of  $\sin x$ ,  $\cos x$ ,  $\log(1+x)$ .

**UNIT-IV****(Lecture-14L+4T, Marks- 25)**

Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighths rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.

**SUGGESTED READINGS**

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
2. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
3. Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd.,

New Delhi, 1995.

4. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi, 1987.
5. Shanti Narayan: A course of Mathematical Analysis, 12<sup>th</sup> revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24<sup>th</sup> Edition, R. Chand & Co., New Delhi, 2003.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis(3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
10. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
11. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Del

### **STAT-SEE-1 Statistical-Data Analysis Using SPSS**

**CREDIT: 2, Marks: 50**

#### **UNIT I**

Learn how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), box plot, stem-leaf, frequency polygon, pie chart, ogives with graphical summaries of data

#### **UNIT II**

Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.

#### **UNIT III**

Random number generation and sampling procedures. Fitting of polynomials and exponential curves. Application Problems based on fitting of suitable distribution, Normal probability plot.

#### **UNIT IV**

Simple analysis and create and manage statistical analysis projects, import data, code editing, Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals.

5L

#### **SUGGESTED READING:**

1. Moore, D.S. and McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H. Freeman
2. Cunningham, B.J (2012): Using SPSS: An Interactive Hands-on approach
3. Cho, M.J., Martinez, W.L. (2014) Statistics in MATLAB: A Primer, Chapman and Hall/CRC

## 4<sup>th</sup> SEMESTER

**STAT-C-401 Statistical Inference**

**CREDIT: 6 (Th- 4, Pr- 2)**

### **UNIT I**

**(Lecture-12, Marks- 15)**

Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators(statement and applications).

### **UNIT II**

**(Lecture-8, Marks- 10)**

Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.

### **UNIT III**

**(Lecture-10, Marks- 13)**

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

### **UNIT IV**

**(Lecture-10, Marks- 12)**

Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among  $\alpha$ ,  $\beta$ , A and B, determination of A and B in

practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.

### **SUGGESTED READINGS:**

1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C.: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G.(1967) Statistical Methods. Iowa State University

### **STAT-C-401(Practical)**

#### **PRACTICAL/LABWORK:**

#### **(End semester 30 + Internal Assessment 5)**

#### **List of Practical**

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
- 4 Maximum Likelihood Estimation
5. Asymptotic distribution of maximum likelihood estimators
6. Estimation by the method of moments, minimum Chi-square
7. Type I and Type II errors
8. Most powerful critical region (NP Lemma)
9. Uniformly most powerful critical region
10. Unbiased critical region
11. Power curves
12. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
13. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
14. Asymptotic properties of LR tests
15. SPRT procedure- Binomial and Poisson

- 16. OC function and OC curve
- 17. ASN function and ASN curve

**STAT-C-402 Linear Models**

**CREDIT: 6 (Th- 4, Pr- 2)**

**UNIT I**

**(Lecture-10, Marks- 13)**

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.

**UNIT II**

**(Lecture-10, Marks- 12)**

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.

**UNIT III**

**(Lecture-10, Marks- 13)**

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models

**UNIT IV**

**(Lecture-10, Marks- 12)**

Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity( Detection and consequences only ).

**SUGGESTED READINGS:**

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons

**STAT-C-402(Practical)**  
**(End semester 30 + Internal Assessment 5)**  
**List of Practical**

1. Estimability when  $X$  is a full rank matrix and not a full rank matrix
2. Distribution of Quadratic forms
3. Simple Linear Regression
4. Multiple Regression
5. Tests for Linear Hypothesis
6. Bias in regression estimates
7. F test for Lack of fit
8. Orthogonal Polynomials
9. Analysis of Variance of a one way classified data
10. Analysis of Variance of a two way classified data with one observation per cell
11. Analysis of Covariance of a one way classified data
12. Analysis of Covariance of a two way classified data

**STAT-C-403 Statistical Quality Control**

**CREDIT: 6 (Th- 4, Pr- 2)**

**UNIT I**

**(Lecture-10, Marks- 12)**

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3- $\sigma$  Control charts, Rational Sub-grouping.

**UNIT II**

**(Lecture-12, Marks- 15)**

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

**UNIT III**

**(Lecture-10, Marks- 13)**

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

**UNIT IV**

**(Lecture-8, Marks- 10)**

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ). Introduction to DMAIC using one case study: Define Phase, Measure Phase, Analyse Phase, Improve Phase and Control Phase.

**SUGGESTED READING:**

1. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011): Applied Statistics, 2<sup>nd</sup> edition revised reprint, Books and

Allied(P) Ltd.

4. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3<sup>rd</sup> Edition reprint, Wiley India Pvt. Ltd.

5. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2<sup>nd</sup> Edition, St. Lucie Press.

6. Hoyle, David (1995): ISO Quality Systems Handbook, 2<sup>nd</sup> Edition, Butterworth Heinemann Publication

### **STAT-C-403(Practical)**

### **(End semester 30 + Internal Assessment 5)**

#### **List of Practical**

1. Construction and interpretation of statistical control charts

i) X-bar & R-chart

ii) X-bar & s-chart

iii) np-chart

iv) p-chart

v) c-chart

vi) u-chart

2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves

3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.

4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.



**STAT-SEE-2 Statistical Techniques for Research Methods      Marks: 50, Credit 2**

**UNIT I**

Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.

**UNIT II**

Survey Methodology and Data Collection, inference and error in surveys, the target populations(sampled population), sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.

**UNIT III**

Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), interpret the results and draw inferences.

**UNIT IV**

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation

**Unit I and II: Assignment**

**Unit III and IV: Practical using knowledge of SEE I**

**SUGGESTED READING:**

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step - by - Step Guide for Beginners, SAGE publications

## **SEMESTER-1**

### **STATISTICS (GENERIC ELECTIVE)**

#### **GE-1 (STAT)**

#### ***STATISTICAL METHODS***

**Credit 6 (Theory 4 + Practical 2)**

**(End semester 50 + Internal Assessment 15)**

#### **UNIT I**

**(Lecture- 11, Marks-12)**

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

#### **UNIT II**

**(Lecture- 11, Marks-15)**

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

#### **UNIT III**

**(Lecture- 11, Marks-15)**

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

#### **UNIT IV**

**(Lecture- 7, Marks-8)**

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

#### **SUGGESTED READING:**

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

**GE-1 (STAT, Practical)**

**(End semester 30 + Internal Assessment 5)**

**(Lecture-10\*)**

**List of Practical**

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Partial and multiple correlations
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

**1 lecture=2 hours**

**SEMESTER-2**

**STATISTICS (GENERIC ELECTIVE)**

**GE-2 (STAT)**

**INTRODUCTORY PROBABILITY**

**Credit 6**

**UNIT I**

**(Lecture=10, Marks-12)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

**UNIT II**

**(Lecture=10, Marks-12)**

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f., c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

**UNIT III**

**(Lecture=10, Marks-12)**

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).

**UNIT IV**

**(Lecture=10, Marks-14)**

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

**SUGGESTED READING:**

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

**PRACTICAL:**

**(Lecture-10\*)**

## **(End semester 30 + Internal Assessment 5)**

### **List of Practical**

1. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$  given
2. Fitting of binomial distributions for  $n$  and  $p$  given
3. Fitting of binomial distributions computing mean and variance
4. Fitting of Poisson distributions for given value of  $\lambda$
5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Problems based on area property of normal distribution
9. To find the ordinate for a given area for normal distribution
10. Application based problems using normal distribution
11. Fitting of normal distribution when parameters are given
12. Fitting of normal distribution when parameters are not given

**\*1 lecture=2 hours**

**N.B.: 1 credit= 10 hours of study**

## **STAT-GE-3 Applied Statistics**

**Credit 6**

### **UNIT I**

**(Lecture=12, Marks-14)**

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential). Measurement of seasonal variations by method of ratio to trend.

### **UNIT II**

**(Lecture=10, Marks-12)**

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.

### **UNIT III**

**(Lecture=10, Marks-12)**

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables:  $\bar{X}$ -bar and R-charts. Control charts for attributes: p and c-charts

### **UNIT IV**

**(Lecture=10, Marks-12)**

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

### **SUGGESTED READING:**

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4<sup>th</sup> Edition(Reprint), Sultan Chand & Sons
4. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

### **PRACTICAL/LAB WORK**

**(End semester 30 + Internal Assessment 5)**

#### **List of Practical**

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation
5. Construction and interpretation of X bar & R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table
9. Computation of measures of fertility and population growth

## **STAT-GE-4 Basics of Statistical Inference**

**Credit 6**

### **UNIT I**

**(Lecture=13, Marks-15)**

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

### **UNIT II**

**(Lecture=12, Marks-12)**

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

### **UNIT III**

**(Lecture=3, Marks-6)**

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

### **UNIT IV**

**(Lecture=14, Marks-17)**

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

### **SUGGESTED READING:**

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley (2005).
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).
3. Dass, M. N. & Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences .(1964, 1977) by John Wiley.

5. Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.

6. Goldstein, A Biostatistics-An introductory text (1971). The Macmillan New York.

### **PRACTICAL/LAB WORK**

**(End semester 30 + Internal Assessment 5)**

#### **List of Practical**

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

