

University of Kalyani



**CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE
IN
STATISTICS (HONOURS)**

**WITH EFFECT FROM THE ACADEMIC SESSION
2018-19**

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN STATISTICS (HONOURS)

INTRODUCTION:

The University Grants Commission (UGC) has taken various measures by means of formulating regulations and guidelines and updating them, in order to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The various steps that the UGC has initiated are all targeted towards bringing equity, efficiency and excellence in the Higher Education System of country. These steps include introduction of innovation and improvements in curriculum structure and content, the teaching-learning process, the examination and evaluation systems, along with governance and other matters. The introduction of Choice Based Credit System is one such attempt towards improvement and bringing in uniformity of system with diversity of courses across all higher education institutes in the country. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective, skill enhancement or ability enhancement courses. The courses shall be evaluated following the grading system, is considered to be better than conventional marks system. This will make it possible for the students to move across institutions within India to begin with and across countries for studying courses of their choice. The uniform grading system shall also prove to be helpful in assessment of the performance of the candidates in the context of employment.

Outline of the Choice Based Credit System being introduced:

1. **Core Course (CC):** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill is termed as an Elective Course.

2.1 **Discipline Specific Elective Course (DSEC):** Elective courses that are offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 **Generic Elective Course (GEC):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

3. Ability Enhancement Courses/ Skill Enhancement Courses:

3.1 **Ability Enhancement Compulsory Course (AECC):** Ability enhancement courses are the courses based upon the content that leads to Knowledge enhancement. They (i) Environmental Science, (ii) English Communication) are mandatory for all disciplines.

3.2 **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

CBCS CURRICULUM FOR SEMESTERIZED UNDER-GRADUATE COURSE IN STATISTICS (HONOURS)

A. TOTAL Number of courses in UG-CBCS (B.A./B.Sc./B.Com. Hons.):

Types of course	Core course (CC)	Elective course		Ability enhancement course		TOTAL
		Discipline specific elective course (DSE)	Generic elective course(GE)	Ability Enhancement compulsory course (AECC)	Skill Enhancement course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

TABLE-1: DETAILS OF COURSES & CREDIT OF B.A./ B.SC./ B.COM.(HONOURS) UNDER CBCS

S. No.	Particulars of Course	Credit Point	
1.	Core Course: 14 Papers	Theory + Practical	Theory + Tutorial
1.A.	Core Course: Theory (14 papers)	14x4 = 56	14x5 = 70
1.B.	Core Course (Practical/Tutorial)* (14 papers)	14x2 = 28	14x1 = 14
2.	Elective Courses: (8 papers)		
2.A.	A. Discipline specific Elective(DSE)(4 papers)	4x4 = 16	4x5 = 20
2.B.	DSE (Practical / Tutorial)* (4 papers)	4x2 =8	4x1 =4
2C.	General Elective(GE) (Interdisciplinary) (4 papers)	4x4 = 16	4x5 = 20
2.D.	GE (Practical / Tutorial)* (4 papers)	4x2 =8	4x1 =4
#Optional Dissertation/ Project Work in place of one DSE paper (6 credits) in 6th semester			
3. Ability Enhancement Courses			
A.	AECC(2 papers of 2 credits each) ENVS, English Communication/ MIL	2x2 = 4	2x2 = 4
B.	Skill Enhancement Course(SEC) (2 papers of 2 credits each)	2x2 = 4	2x2 = 4
Total Credit:		140	140
## Wherever there is a practical, there will be no tutorial and vice-versa.			

TABLE-2: SEMESTERWISE DISTRIBUTION OF COURSE & CREDITS IN B.A./B.SC./B.COM. HONS

Courses/ (Credits)	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Total No. of Courses	Total credit
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1			--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	--
Total Credit /Semester	20	20	26	26	24	24	-----	140

❖ **COURSE CODE & COURSE TITLE:**

A. Core courses (CC)

1. STATHCC-1: Descriptive Statistics
2. STATHCC-2: Probability and Probability Distributions I
3. STATHCC-3: Mathematical Analysis
4. STATHCC-4: Probability and Probability Distributions II
5. STATHCC5: Linear Algebra and Numerical Analysis
6. STATHCC-6: Demography and Vital Statistics
7. STATHCC-7: Statistical Computing using C/C++
8. STATHCC-8: Survey Sampling and Indian Official Statistics
9. STATHCC-9: Statistical Inference-I and Sampling Distribution
10. STATHCC-10: Economic Statistics
11. STATHCC-11: Statistical Inference-II
12. STATHCC-12: Linear Models
13. STATHCC-13: Design of Experiments
14. STATHCC-14: Multivariate Analysis and Nonparametric Methods

B. Discipline specific elective courses (DSE)

1. STATHDSE-1: Statistical Quality Control/Econometrics
2. STATHDSE-2: Operations Research/Financial Statistics
3. STATHDSE-3: Survival Analysis/Stochastic Processes and Queuing Theory
4. STATHDSE-4: Project Work/Actuarial Statistics

C. Generic elective courses (GE):

1. STATHGGE-1: Statistical Methods
2. STATHGGE-2: Introductory Probability
3. STATHGGE-3: Basics of Statistical Inference
4. STATHGGE-4: Applied Statistics

D. Ability enhancement compulsory courses (AECC)

1. AECC-01: ENVS
2. AECC-02: English Communication/MIL

E. Skill enhancement courses (SEC)

1. STATHSEC-1: Statistical Data Analysis using MS EXCEL/MINITAB
2. STATHSEC-2: Research Methodology/Monte Carlo Method

**TABLE-3: SEMESTER & COURSEWISE CREDIT DISTRIBUTION IN IN B.A./B.COM/B.SC.(Hons.)
(6 Credit: 75 Marks)**

SEMESTER-I			
Course Code	Course Title	Course wise Class (L+T+P)	Credit
STATHCC-1 (for Stat Hons)	Descriptive Statistics (Th)	50	4
	Descriptive Statistics Lab (Prac)	25	2
STATHCC-2 (for Stat Hons)	Probability and Probability Distributions- I (Th)	50	4
	Probability and Probability Distributions I Lab (Prac)	25	2
STATHGGE-1	(Any discipline other than Statistics)	75	6
AECC-1	ENVS		2
Total	4 courses	Total	20
SEMESTER-II			
Course Code	Course Title	Course wise Class	Credit
STATHCC-3 (for Stat Hons)	Mathematical Analysis (Th)	75	6
STATHCC-4 (for Stat Hons)	Probability and Probability Distributions -II (Th)	50	4
	Probability and Probability Distributions- II Lab (Prac)	25	2
STATHGGE-2	(Any discipline other than Statistics)	75	6
AECC-2	English Communication/MIL		2
Total	4 courses	Total	20
SEMESTER-III			
Course Code	Course Title	Course wise Class	Credit
STATHCC-5 (for Stat Hons)	Linear Algebra and Numerical Analysis (Th)	75	6
STATHCC-6 (for Stat Hons)	Demography and Vital Statistics (Th)	50	4
	Demography and Vital Statistics Lab (Prac)	25	2
STATHCC-7 (for Stat Hons)	Statistical Computing using C/C++ Programming (Th)	25	2
	Statistical Computing using C/C++ Programming Lab (Prac)	50	4
STATHSEC-1 (for Stat Hons)	Statistical Data Analysis using MSEXCEL	25	2
	OR Statistical Data Analysis using MINITAB	25	
STATHGGE-3	(Any discipline other than Statistics)	75	6
Total	5 courses	Total	26
SEMESTER-IV			
Course Code	Course Title	Course wise Class	Credit

STATHCC-8 (for Stat Hons)	Survey Sampling and Indian Official Statistics (Th)	50	4
	Survey Sampling and Indian Official Statistics Lab (Prac)	25	2
STATHCC-9 (for Stat Hons)	Statistical Inference - I and Sampling Distribution (Th)	50	4
	Statistical Inference - I and Sampling Distribution Lab (Prac)	25	2
STATHCC-10 (for Stat Hons)	Economic Statistics (Th)	50	4
	Economic Statistics Lab (Prac)	25	2
STATHSEC-2 (for Stat Hons)	Research Methodology	25	2
	OR Monte Carlo Method	25	
STATHGGE-4	(Any discipline other than Statistics)	75	6
Total	5 courses	Total	26
SEMESTER-V			
Course Code	Course Title	Course wise Class	Credit
STATHCC-11 (for Stat Hons)	Statistical Inference - II Lab (Th)	50	4
	Statistical Inference - II Lab (Prac)	25	2
STATHCC-12 (for Stat Hons)	Linear Models (Th)	50	4
	Linear Models Lab (Prac)	25	2
STATHDSE-1 (for Stat Hons)	Statistical Quality Control (Th)	50	4
	Statistical Quality Control Lab (Prac)	25	2
	OR		
	Econometrics (Th)	50	4
	Econometrics Lab (Prac)	25	2
STATHDSE-2 (for Stat Hons)	Operations Research (Th)	50	4
	Operations Research Lab (Prac)	25	2
	OR		
	Financial Statistics (Th)	50	4
	Financial Statistics Lab (Prac)	25	2
Total	4 courses	Total	24
SEMESTER-VI			
Course Code	Course Title	Course wise Class	Credit
STATHCC-13 (for Stat Hons)	Design of Experiments (Th)	50	4
	Design of Experiments Lab (Prac)	25	2
STATHCC-14 (for Stat Hons)	Multivariate Analysis and Nonparametric Methods (Th)	50	4
	Multivariate Analysis and Nonparametric Methods Lab (Prac)	25	2

STATHDSE-3 (for Stat Hons)	Survival Analysis (Th)	50	4
	Survival Analysis Lab (Prac)	25	2
	OR		
	Stochastic Processes and Queuing Theory (Th)	50	4
	Stochastic Processes and Queuing Theory Lab (Prac)	25	2
STATHDSE-4 (for Stat Hons)	Project Work		6
	OR		
	Actuarial Statistics (Th)	50	4
	Actuarial Statistics Lab (Prac)	25	2
Total	4 courses	Total	24
Total (All semesters)	26 courses	Total	140

**Detaild Course & Contents of each subject specific syllabus will be given as per existing standard format as provided below.*

B.A./B.Com/B.Sc. STATISTICS (Honours)

SEMESTER-I

STATHCC-1 Descriptive Statistics

After completion of the course students will be able to learn different techniques of representation of statistical data. They will know different descriptive measures associated with data. Exposure on index numbers and their uses will also be given.

Descriptive Statistics (Th) 4 Credits

Unit 1

1. Statistics: Definition and scope, concepts of statistical population and sample.
2. Data: quantitative and qualitative,
3. Scales of measurement: nominal, ordinal, interval and ratio. Frequency distribution.
4. Presentation: tabular and graphical, including histogram and ogives.

Unit 2

1. Measures of Central Tendency: Mean, Median, Mode.
2. Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation, Gini's Coefficient, Lorenz Curve. Moments, skewness and kurtosis, Quantiles and measures based on them. Box Plot. Outlier Detection. Quantile-Quantile Plot.

Unit 3

1. Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares.
2. Analysis of Categorical Data: Contingency table, association of attributes, odds ratio, Pearson's measure, Goodman- Kruskal's. Binary response and logistic regression. Spearman's Rank correlation.

Unit 4

Index Numbers: Weighted means, price and quantity index numbers, choice of weights, Laspeyres' and Paasche's index numbers. Tests of index numbers and Fisher's ideal index number.

Descriptive Statistics Lab (Prac) 2 Credits

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 quadratic and exponential function.
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's rank correlation.
11. Box Plot and Q-Q Plot.
12. Calculation of price and quantity index numbers.

Suggested Reading

- Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- 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.
- Tukey, J.W. (1977): Exploratory Data Analysis, Addison-Wesley Publishing Co.
- Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
- Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company.

STATHCC-2 Probability and Probability Distributions-I

After completion of the course students will be able to learn elementary theory probability and random variables which form the basis of statistical theory.

Probability and Probability Distributions-I (Th) 4 Credits

Unit 1

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic.

Unit 2

Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Unit 3

1. Random variables: discrete random variables, p.m.f. and c.d.f., statement of properties of c.d.f, illustrations and properties of random variables.
2. Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform.

Unit 4

Two dimensional random variables: discrete type, joint, marginal and conditional p.m.f and c.d.f., statement of properties of c.d.f, independence of variables, trinomial distribution.

Probability and Probability Distributions-I Lab (Prac) 2 Credits

List of Practical:

1. Application problems based on Classical Definition of Probability.
2. Application problems based on Bayes Theorem.
3. Fitting of binomial distributions for n and $p = q = \frac{1}{2}$.
4. Fitting of binomial distributions for given n and p .
5. Fitting of binomial distributions after computing mean and variance.
6. Fitting of Poisson distributions for given value of λ .
7. Fitting of Poisson distributions after computing mean.
8. Fitting of negative binomial distribution.
9. Fitting of suitable distribution.
10. Application problems based on binomial distribution.
11. Application problems based on Poisson distribution.
12. Application problems based on negative binomial distribution.

Suggested Reading

Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.

Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.

Goon, A.M., Gupta, M.K. & Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press.

Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley .

Uspensky, J.V. (1937): Introduction to Mathematical Probability, McGraw Hill.

Cacoullos, T. (1973): Exercises in Probability. Narosa.

Rahman, N.A. (1983): Practical Exercises in Probability and Statistics, Griffen.

Ross, S. (2002): A First Course in Probability, Prentice Hall.

Generic Elective (For the students of other Subject/ Discipline)

STATHGGE-1 Statistical Methods

After completion of the course the learners will be able to deal with different representations, analyses and interpretations of statistical data, at least at a primary level.

Statistical Methods (Th) 4 Credits

Unit 1

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. Frequency distribution, **Presentation:** tabular and graphic, including histogram and ogives.

Unit 2

1. **Measures of Central Tendency** :mathematical and positional.

2. **Measures of Dispersion**: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

Unit 3

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

Unit 4

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

Statistical Methods Lab (Prac) 2 Credits

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.

Suggested Reading

- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- 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.
- Goon A.M., Gupta M.K. and Dasgupta B. : Basic Statistics. The World Press, Kolkata.
- Chakraborty, Arnab (2016) : Probability and Statistics. Sarat Book House

SEMESTER-II

STATHCC-3 Mathematical Analysis

After completion of the course students will have a background on the mathematical preliminaries useful for statistics.

Mathematical Analysis (Th) 6 Credits

Unit 1

Representation of real numbers as points on a line. Algebraic, Order and Completeness properties of \mathbb{R} (Concepts only). Bounded and unbounded sets, neighbourhood of a point, Supremum and infimum.

Functions, Countable, Uncountable sets and Uncountability of \mathbb{R} . Sequences and their convergence, monotonic sequences, bounded sequences, squeeze theorem. Limits of some

special sequences such as r^n , $(1 + 1/n)^n$ and $n^{1/n}$.

Infinite series, positive termed series and their convergence, comparison test, ratio test and root test. Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

Unit 2

Review of limit, continuity and differentiability. Indeterminate form, L' Hospital's rule. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's form of remainder (without proof). Taylor's series expansions of $\sin x$, $\cos x$, e^x , $(1 + x)^n$ and $\log(1+x)$.

Maxima and Minima of Functions. Successive Differentiation.

Unit 3

Integral Calculus: definite integral (definition). Statements of properties, Fundamental Theorem of Integral Calculus.

Improper Integral, Beta and Gamma functions: properties and relationship between them.

Unit 4

Functions of two variables and Partial Derivatives. Maxima and Minima of such Functions. Constrained Maximization and minimization, use of Lagrange Multiplier. Double Integral (intuitive-graphical approach), change of order of integration, transformation of variables and Jacobians (statement of relevant theorems and their uses)

STATHCC-4 Probability and Probability Distributions –II

After completion of the course students will be able to learn different probability distributions useful in statistics.

Probability and Probability Distributions –II (Th) 4 Credits

Unit 1

Continuous random variables, p.d.f. and c.d.f., illustrations and properties, univariate transformations with illustrations. Two dimensional random variables: continuous type, joint, marginal and conditional, p.d.f., and c.d.f.. Independence of two variables.

Unit 2

Mathematical Expectation (discrete and continuous): Single & bivariate random variables and their properties. Probability generating function. Moments. Moment generating function. Correlation coefficient, Conditional expectation and variance.

Probability Inequalities: Markov & Chebyshev.

Unit 3

Standard continuous probability distributions: uniform, normal, exponential, Cauchy, beta, gamma, lognormal, logistic, double exponential and Pareto along with their properties and limiting/approximation cases.

Unit 4

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Probability and Probability Distributions -II Lab (Prac) 2 Credits

1. Problems based on area property of normal distribution.
2. To find the ordinate for a given area for normal distribution.
3. Application based problems using normal distribution.
4. Fitting of normal distribution when parameters are given.
5. Fitting of normal distribution when parameters are not given.
6. Problems similar to those in 1 to 5 in cases of other continuous distributions.

Suggested Reading

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

Generic Elective

(For the students of other Subject/ Discipline)

STATHGGE-2

After completion of the course the learners will be able to grasp the theory of probability and distributions that are useful in drawing inferences from statistical data.

Introductory Probability (Th) 4 Credits

Unit 1

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 2

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 3

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 4

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

Introductory Probability Lab (Prac) 2 Credits

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 λ
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

Suggested Reading

- Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
- Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi
- Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

- Chakraborty, Arnab (2016): Probability and Statistics. Sarat Book House.
- Ross, S. (2002): A First Course in Probability, Prentice Hall.

SEMESTER-III

STATHCC-5 Linear Algebra and Numerical Analysis

After completion of the course students will be able to learn vector and matrix algebra. Knowledge of numerical techniques will also be achieved.

Linear Algebra and Numerical Analysis (Th) Credit 6

Linear Algebra

Unit 1

Vector: Vector space with a field of real numbers, addition and scalar multiplication of vectors, linear combination and linear independence, basis, dimension, subspace, inner-product, orthogonality and Gram-Schmidt orthogonalization process. (8L)

Unit 2

Matrix: Definition, various types of matrices, matrix operations, elementary matrices, rank of a matrix and related results, inverse of a matrix, determinants, cofactors, properties of determinants, Laplace expansion, determinant and inverse of a partitioned matrix, reduction of a matrix to normal form, sweep-out and pivotal condensation methods, triangular reduction.

Homogeneous and non-homogeneous system of linear equations, consistency.

Characteristic equation, eigenvalues and eigenvectors and simple related results regarding real symmetric matrices.

Quadratic forms: classification, canonical reduction, spectral decomposition. (18L)

Numerical Analysis

Unit 3

Approximation of numbers and functions, absolute and relative errors, Δ and E operators, separation of symbols using Δ and E operators.

Difference table, interpolation by Newton's forward and backward formula with error terms, Lagrange's formula, divided difference table, Newton's divided difference formula, Stirling's and Bessel's central difference interpolation formula. (10L)

Unit 4

Numerical differentiation and its applications.

Numerical integration, quadrature formula, trapezoidal, Simpson's $\frac{1}{3}$ rd and $\frac{3}{8}$ th rules.

Numerical solution of equations, bisection, iterative and Newton-Raphson methods in one unknown, conditions of convergence, extension to two unknowns.

Euler-Maclaurin's sum formula, Stirling's approximation to $n!$ (10L)

Suggested Reading:

1. Shanti Narayan: A Text Book on Matrices, S. Chand
2. Hadley, G: Linear Algebra, Addison Wesley, Narosa.
3. Rao, A. R. and Bhimasankaram, P.: Linear Algebra.
4. Scarborough, J. B.: Numerical Mathematical Analysis, Oxford University Press.
5. Saxena, H. C.: The Calculus of Finite Differences, S. Chand.
6. Freeman, H.: Finite Differences for Actuarial Students, Cambridge University Press.
7. Aitkinson, K.: Elementary Numerical Analysis, Wiley.

STATHCC-6 Demography and Vital Statistics

After completion of the course students will be able to learn applications of statistics in studying different vital events and demographic issues.

Demography and Vital Statistics (Th) Credit 4

Unit 1

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. (10L)

Unit 2

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.

Graduation of mortality rates by Gompertz and Makeham's laws, logistic curve and its fitting by Rhodes' method for population forecasting. (15L)

Demography and Vital Statistics (Th) Credit 2

List of Practical:

1. Calculation of different birth and death rates.
2. Construction of life tables
3. Calculation of different fertility rates.
4. Graduation of mortality rates by Gompertz law.
5. Logistic curve fitting by Rhodes' method

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, 4th

STATHCC-7 Statistical Computing using C/C++

After completion of the course students will be able to learn C/C++ language with special emphasis on solving problems of statistics.

Statistical Computing using C/C++ (Th) Credit 2

Unit 1

History and importance of C/C++. Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/C++ program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data.

Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data

Unit 2

Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional (?) operator. Looping in C/C++: for, nested for, while, do...while, jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

Unit 3

User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values , arguments with return values, no arguments but returns a value, functions that return multiple values. Recursion function. Passing arrays to functions, Storage class of Variables.

Unit 4

Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers

Structure: Definition and declaring, initialization, accessing structure members, copying and comparison of structure variables, array of structures, structure pointers. Dynamic memory allocation functions :malloc, calloc and free.

Pre processors: Macro substitution, macro with argument

File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

Statistical Computing using C/C++ (Prac) Credit 4

List of Practical:

1. Plot of a graph $y = f(x)$
2. Roots of a quadratic equation (with imaginary roots also)
3. Sorting of an array and hence finding median
4. Mean, Median and Mode of a Grouped Frequency Data
5. Preparing a frequency table
6. Random number generation from uniform, exponential, normal and gamma distribution, calculate sample mean and variance and compare with population parameters.
7. Matrix addition, subtraction, multiplication Transpose and Trace
8. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit
9. Chi-square contingency table
10. t-test for difference of means
11. Paired t-test
12. F-ratio test
13. Multiple and Partial correlation
14. Compute ranks and then calculate rank correlation(without tied ranks)
15. Fitting of lines of regression

Suggested Reading:

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2nd Edition, Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
3. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill.

STATHSEC-1 Statistical Data Analysis Using MS EXCEL/MINITAB

Statistical Data Analysis Using MS EXCEL Credit 2

After completion of the course students will be able to learn different EXCEL/MINITAB commands useful for statistical analysis of data.

- (i) Use of Spreadsheet.
- (ii) Drawing diagrams – bar, column, line, pie, scatter.
- (iii) Use of functions – mathematical, statistical and logical.
- (iv) Line diagrams showing different types of time series data, determination of trend by moving averages and curve fitting methods, plotting fitted values.
- (v) Exponential smoothing of a time series.

Statistical Data Analysis Using MINITAB Credit 2

After completion of the course students will be able to learn different MINITAB commands useful for statistical analysis of data.

Use of MINITAB using the options under 'CALCULATION' and 'STATISTICS'.

Some suggested problems:

- (i) Basic statistics – display, descriptive measures (univariate only), one-sample z and t tests, two-sample and paired t tests for proportion, tests for one and two variances and correlations.
- (ii) Regression: Linear and multiple regression – fitted and residual plots.
- (iii) ANOVA: one-way and two-way classified data.
- (iv) Control charts: mean, mean-range, mean-s.d., proportion, number of defectives, number of defects charts.

Generic Elective

(For the students of other Subject/ Discipline)

STATHGGE-3 Basics of Statistical Inference

After completion of the course the learners will be able to know how inferences e.g. statistical estimation and hypothesis testing are carried out for different types of data.

Basics of Statistical Inference (Th) Credit 4

Unit 1

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 2

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

Unit 3

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

Unit 4

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.

Basics of Statistical Inference (Prac) Credit 2

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.

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. Das, 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.

SEMESTER-IV

STATHCC-8

Survey Sampling and Indian Official Statistics

After completion of the course students will be able to learn survey sampling methodology and its uses in real life problems. They will also know the official system of India and different official publications.

Survey Sampling and Indian Official statistics (Th) Credit 4

Unit 1

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 2

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, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total,

variances of these estimates ($N=nxk$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Unit 3

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 subsampling.

Unit 4

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.

Survey Sampling and Indian Official Statistics (Pr) Credit 2

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.

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

STATHCC-9 Statistical Inference -I and Sampling Distribution

After completion of the course students will be able to learn basic concepts of statistical inference. They will also learn how to derive distributions of statistics calculated from samples.

Statistical Inference - I and Sampling Distribution (Th) Credit 4

Unit 1

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 2

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

Unit 3

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 4

Exact sampling distribution: Definition and derivation of p.d.f. of χ^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 χ^2 distribution. 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 χ^2 distributions. Test of significance and confidence Intervals based on t and F distributions.

Statistical Inference –I and Sampling Distribution (Prac) Credit 2

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. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators
5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators

8. Estimation by the method of moments, minimum Chi-square
9. Applications of simple tests of significance
10. Applications of large sample tests of significance using CLT.

Suggested Reading:

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

STATHCC-10 Economic Statistics

After completion of the course students will be able to learn applications of statistics in economics and time series.

Economic Statistics (Th) Credit 4

Unit 1

Chain-base index numbers, tests for index numbers: time and factor reversal tests, circular test. Some important indices: consumer price index, wholesale price index – methods of construction and uses.

Unit 2

Introduction: Examples of time series from various fields, components of a times series, additive and multiplicative models. Trend and seasonal components: estimation of trend by linear filtering (simple and weighted moving averages)and curve fitting (polynomial, exponential and Gompertz), detrending, estimation of seasonal component by ratio-to-moving-average method, ratio to trend method, deseasonalization.

Unit 3

Stationary Time series: weak stationarity, autocorrelation function and correlogram. Some Special Processes: moving-average (MA) process and autoregressive (AR) process of orders oneand two, estimation of the parameters of AR(1) and AR(2) – Yule-Walker equations. Exponential smoothing method of forecasting.

Unit 4

Theory and analysis of consumer demand: law of demand, price elasticity of demand, Engel curve – its different forms and properties, income elasticity of demand, estimation of Engel curves from family budget data by weighted least squares method.

Economic Statistics (Prac) Credit 2

1. Calculation of price and quantity index numbers using simple and weighted average of price relatives.
2. To calculate the Chain Base index numbers.
3. To calculate consumer price index number.
4. Fitting of trend by moving average and mathematical curve fitting method.
5. Determination of seasonal indices.
6. Exponential smoothing
7. Computation of income elasticity of demand from family budget data.
8. Estimation of Engel curve.

Suggested Reading:

1. Gun, A. M., Gupta, M. K. & Dasgupta, B.: Fundamentals of Statistics vol II, World Press.
2. Mukhopadhyay, P.: Applied Statistics.
3. Prais & Houthakker: Analysis of Family Budget Data.
4. Kendall. M. G. & Stuart, A.: The Advanced Theory of Statistics, Vol III, Charles Griffin.
5. Chatfield, C.: The Analysis of Time Series – An Introduction, Chapman & Hall.
6. Allen, R. G. D.: Index Numbers in Theory and Practice, Macmillan.
7. Brockwell, P. J. & Davis, R. A.: Introduction to Time Series and Forecasting, Springer-Verlag.

STATHSEC-2 Research Methodology/Monte Carlo Method

Research Methodology Credit 2

After completion of the course students will be able to learn what are the different stages of research, how a good research is conducted, how different statistical analyses and their interpretations are incorporated in the thesis. They will also learn techniques of report writing.

Unit 1

Introduction to research, meaning of research, role of research in important areas, process of research, types of research, Unit of analysis, characteristics of interest. Research problem as a problem of hypothesis testing.

Unit 2

Data Processing: Introduction, editing of data, coding of data, classification of data, tables as data presentation devices, graphical presentation of data

Unit 3

Data Analysis: An overview on techniques in univariate, bivariate and multivariate data
Models and Model Building: role of models, types of models, objectives of modeling, model building/ model development, model validation, simulation models.

Unit 4

Formats of Reports: introduction, parts of a report, cover and title page, introductory pages, text, reference section, typing instructions, copy reading, proof reading.
Presentation of a report: introduction, communication dimensions, presentation package, audio-visual aids, presenter's poise.

Suggested Reading

Kotahri, C.R (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed. Reprint, New Age International Publishers

2. Lilien, Gary L. and Philip Kotler, 1983. Marketing Decision Making; A Model Building Approach, Harper & Row, New York.

3. Shenoy, GVS, et al., (1983). Quantitative Techniques for Managerial Decision Making, Wiley Eastern.

Monte Carlo Method Credit 2

After completion of the course students will be able to learn different techniques of simulation useful in statistics.

Unit 1

The need for Monte Carlo Techniques; history; example applications. .Rejection method; variance reduction; importance sampling.

Unit 2

convergence of Markov chains; detailed balance; limit theorems.

Unit 3

4. **Basic MCMC algorithms:** Metropolis-Hastings algorithm; Gibbs sampling.

Unit 4

Implementational issues: Burn In; Convergence diagnostics, Monte Carlo error.

Suggested Reading:

1. C.P.Robert and G.Casella, Monte Carlo Statistical Methods (2nd Ed.), Springer, 2004.

2. J. Voss "An introduction to Statistical Computing: A Simulation-Based Approach"

3. J.S. Liu, Monte Carlo Strategies in Scientific Computing, Springer, 2001.

Generic Elective

(For the students of other Subject/ Discipline)

STATHGGE-4 Applied Statistics

After completion of the course the learners will be able to know different applications of statistics in economy, time series, industrial statistics, demography etc.

Applied Statistics(Th) Credit 4

Unit 1

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 2

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 3

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: X- bar and R-charts. Control charts for attributes: p and c-charts

Unit 4

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.

Applied Statistics(Prac) Credit 2

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 \bar{X} & 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

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, 4th Edition(Reprint), Sultan Chand & Sons
4. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

SEMESTER-V

STATHCC-11 Statistical Inference- II

After completion of the course students will be able to learn the theories of hypothesis testing, specially the Neyman-Pearson theory, useful in drawing inference from observations.

Statistical Inference II (Th) Credit 4

Unit 1

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.

Unit 2

Best critical region, most powerful test, uniformly most powerful test, Neyman-Pearson Lemma (statement, proof of sufficiency part and applications to construct most powerful tests and uniformly most powerful tests). Unbiased test, Definition of UMPU test.

Unit 3

Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit 4

Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among α , β , 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 and binomial distributions.

Statistical Inference- II (Prac) Credit 2

List of Practical

1. Type I and Type II errors
2. Most powerful critical region (NP Lemma)
3. Uniformly most powerful critical region
4. Unbiased critical region
5. Power curves
6. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
7. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
8. Asymptotic properties of LR tests
9. SPRT procedure
10. OC function and OC curve
11. ASN function and ASN curve

Suggested Reading:

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

STATHCC-12 Linear Models

After completion of the course students will be able to learn the Gauss-Markov theory of linear models and its applications.

Linear Models (Th) Credit 4

Unit 1

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 2

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 3

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 4

Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots

Linear Models (Prac) Credit 2

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. 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

Suggested Reading

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.
4. Kshirsagar. Linear Models
5. Scheffe, H. Analysis of Variance. Wiley.

STATHDSE-1 Statistical Quality Control/Econometrics

Statistical Quality Control (Th) Credit 4

After completion of the course students will be able to learn how statistical techniques are used in controlling the quality of products in industries by means of different control charts and sampling inspection plans.

Unit 1

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.

Unit 2

Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3- σ Control charts, Rational Sub-grouping.

Unit 3

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. Analysis of patterns on control chart, estimation of process capability.

Unit 4

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.

Statistical Quality Control (Prac) Credit 2

1. Construction and interpretation of statistical control charts:

- X-bar & R-chart
- X-bar & s-chart
- np-chart
- p-chart
- c-chart
- 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.

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, 2nd edition revised reprint, Books and Allied(P) Ltd.
4. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
5. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.

Econometrics (Th) Credit 4

After completion of the course students will be able to learn how statistical techniques are used in econometric measurements.

Unit 1

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions.

Unit 2

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.

Unit 3

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

Unit 4

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models, Dummy variables, Qualitative data.

Econometrics (Prac) Credit 2

List of Practical

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems concerning specification errors
5. Problems related to consequences of Multicollinearity
6. Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Diagnostics of Autocorrelation

STATHDSE-2 Operations Research/Financial Statistics

Operations Research (Th) Credit 4

After completion of the course students will be able to learn how optimization techniques are used in solving problems in real-life situations including transportation, inventory, game etc.

Unit 1

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Post-optimality analysis

Unit 2

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special

cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.

Unit 3

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix

and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.

Unit 4

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

Operations Research (Prac) Credit 2

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation
 - a. Degenerate solution
 - b. Unbounded solution
 - c. Alternate solution
 - d. Infeasible solution
3. Allocation problem using Transportation model
4. Allocation problem using Assignment model
5. Problems based on game matrix
 - a. Graphical solution to $m \times n$ rectangular game
 - b. Mixed strategy
6. To find optimal inventory policy for EOQ models and its variations

Suggested Reading

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill

Financial Statistics (Th) Credit 4

After completion of the course students will be able to learn basic applications of statistics in finance.

Unit 1

Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models with state dependent increments.

Unit 2

Tools Needed For Option Pricing: Wiener process, stochastic integration, and stochastic differential equations. Introduction to derivatives: Forward contracts, spot price, forward price, future price. Call and put options, zero-coupon bonds and discount bonds

Unit 3

Pricing Derivatives: Arbitrage relations and perfect financial markets, pricing futures, put-call parity for European options, relationship between strike price and option price. Stochastic Models in Finance: Discrete time process- binomial model with period one.

Unit 4

Stochastic Models in Finance: Continuous time process- geometric Brownian motion. Ito's lemma, Black-Scholes differential equation, Black-Scholes formula for European options, Hedging portfolios: Delta, Gamma and Theta hedging. Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends

Financial Statistics (Prac) Credit 2

List of Practical

1. To verify “no arbitrage” principle
2. To verify relationship between spot price, forward price, future price
3. To price future contracts
4. To verify put-call parity for European options
5. To construct binomial trees and to evaluate options using these trees
6. To price options using Black – Scholes formula
7. To hedge portfolios using delta and gamma hedging
8. To hedge portfolios theta hedging
9. Pricing of call options using binomial model
10. Computation of dividends on call options as a percentage of stock price.
11. Computation of dividends on call options as a fixed amount of money.
12. Pricing of put options using binomial model
13. Call-put parity for options following binomial models.
14. Effect of dividends on put options.

Suggested Reading

1. Franke, J., Hardle, W.K. and Hafner, C.M. (2011): Statistics of Financial Markets: An Introduction, 3rd Edition, Springer Publications.
2. Stanley L. S. (2012): A Course on Statistics for Finance, Chapman and Hall/CRC.

SEMESTER-VI

STATHCC-13 Design of Experiments

After completion of the course students will be able to learn techniques of designing experiments and analysis of data.

Design of Experiments (Th) Credit 4

Unit 1

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.

Unit 2

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD,.

Unit 3

Factorial experiments: advantages, notations and concepts, 2^2 , $2^3 \dots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$) and 3^2 factorial experiments in a single replicate.

Unit 4

Fractional factorial experiments: Construction of one-half and one-quarter fractions of 2^n ($n \leq 5$) factorial experiments, Alias structure, Resolution of a design.

Design of Experiments (Pr) Credit 2

List of Practical

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. Analysis of an RBD with one missing observation
5. Analysis of an LSD with one missing observation
6. Intra Block analysis of a BIBD
7. Analysis of 2^2 and 2^3 factorial in CRD and RBD
8. Analysis of 2^2 and 2^3 factorial in LSD
9. Analysis of a completely confounded two level factorial design in 2 blocks
10. Analysis of a completely confounded two level factorial design in 4 blocks
11. Analysis of a partially confounded two level factorial design
12. Analysis of a single replicate of a 2^n design

Suggested Reading

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

STATHCC-14 Multivariate Analysis and Nonparametric Methods

After completion of the course students will be able to basic theories on handling data on several variables, including Discriminant Analysis and Principal Component Analysis.

Multivariate Analysis and Nonparametric Methods (Th) Credit 4

Unit 1

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

Unit 2

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient and their properties.

Unit 3

Applications of Multivariate Analysis: Discriminant Analysis, Principal Components Analysis and Factor Analysis.

Unit 4

Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

Multivariate Analysis and Nonparametric Methods (Prac) Credit 2

List of Practical

1. Multiple Correlation
2. Partial Correlation
3. Bivariate Normal Distribution,
4. Multivariate Normal Distribution
5. Discriminant Analysis
6. Principal Components Analysis
7. Factor Analysis
8. Test for randomness based on total number of runs,
9. Kolmogorov Smirnov test for one sample.
10. Sign test: one sample, two samples, large samples.
11. Wilcoxon-Mann-Whitney U-test
12. Kruskal-Wallis test

Suggested Reading

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn.,

Pearson & Prentice Hall

5. Mukhopadhyay, P. :Mathematical Statistics.

6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Ed.

STATHDSE-3 Survival Analysis/Stochastic Processes and Queuing Theory

Survival Analysis (Th) Credit 4

After completion of the course students will be able to learn various life distributions, estimation of various functions related to survival data and basic concepts of epidemiology.

Unit 1

Survival Analysis: Functions of survival times, survival distributions and their application exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function.

Unit 2

Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

Unit 3

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model.

Unit 4

Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.

Survival Analysis (Prac) Credit 2

List of Practical

1. To estimate survival function
2. To determine death density function and hazard function
3. To identify type of censoring and to estimate survival time for type I censored data
4. To identify type of censoring and to estimate survival time for type II censored data
5. To identify type of censoring and to estimate survival time for progressively type I censored data
6. Estimation of mean survival time and variance of the estimator for type I censored data
7. Estimation of mean survival time and variance of the estimator for type II censored data
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data
9. To estimate the survival function and variance of the estimator using Non-parametric

methods with Kaplan-Meier method

Suggested Reading

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival Data Analysis, 3rd Edition, John Wiley and Sons.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer.

Stochastic Processes and Queuing Theory (Th) Credit 4

After completion of the course students will be able to learn applications of probably theory in stochastic processes including Markov Chains, Poisson Processes, Queuing models etc.

Unit 1

Probability Distributions: Generating functions, Bivariate probability generating function.
Stochastic Process: Introduction, Stationary Process.

Unit 2

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system.

Unit 3

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

Unit 4

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

Stochastic Processes and Queuing Theory (Pr) Credit 2

List of Practical

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour

of queue as N tends to infinity.

12. Calculation of generating function and expected duration for different amounts of stake.

13. Computation of probabilities and expected duration between players.

Suggested Reading

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

STATHDSE-4 Project Work / Actuarial Statistics

Project Work Credit 6

Actuarial Statistics (Th) Credit 4

After completion of the course the learners will be able to learn how statistical techniques are used in insurance applications. They will know how premium rates, annuities etc. are calculated.

Unit 1

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

Unit 2

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

Unit 3

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

Unit 4

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

Actuarial Statistics (Prac) Credit 2

List of Practical

1. Risk computation for different utility models
2. Discrete and continuous risk calculations
3. Calculation of aggregate claims for collective risks
4. Calculation of aggregate claim for individual risks
5. Computing Ruin probabilities and aggregate losses
6. Annuity and present value of contract
7. Computing premium for different insurance schemes
8. Practical based on life models and tables

Suggested Reading

1. Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.