

SYLLABUS
for
Choice Based Credit System
(CBCS)

On the basis of
Outcome Based Education
(OBE)

STATISTICS HONOURS

PATNA WOMEN'S COLLEGE

Autonomous

PATNA UNIVERSITY

3rd Cycle NAAC Accredited at 'A' Grade with CGPA 3.58/4
"College with Potential for Excellence" (CPE) Status Accorded by UGC

Vision

Rooted in the life, vision, and teachings of Jesus Christ and inspired by Mother Veronica, the foundress of the Apostolic Carmel, Patna Women's College strives to become a centre of academic excellence in higher education, social responsibility, and empowerment of women.

Mission Statement

Patna Women's College, the first college for women in Bihar, is committed to the holistic development of women so as to make an effective contribution to the creation of a better society.

To this end, we strive

- To become a center of excellence in higher education for women in an atmosphere of autonomy.
- To excel in teaching-learning, research, and consultancy.
- To provide education that promotes capacity building and holistic development of a person.
- To offer subjects for competency building and motivate/animate a workforce imbued with human values.
- To promote patriotism, communal harmony and cultural integration to maintain a free and peaceful atmosphere on the campus.
- To train the students in creative arts, social service, critical thinking, and leadership in order to make an effective contribution to the creation of a new and value-based society.
- To create women leaders and to make them agents of social change.
- To develop skill oriented and value-based courses, for the all-round development of individuals.
- To promote academic exchange and academia-industry interface.
- To form young women who are 'always wise' and who will dare to 'go ahead and conquer knowledge' through, competence, commitment, delicate conscience, and compassion.

PROGRAM OUTCOMESS (POs)

Upon completion of the programme, the students will attain the ability to:

PO1: Examine various hypotheses involved, and identify and consult relevant resources to find their rational answers.

PO2: Develop capability to identify logical flaws and loopholes in the arguments of practicing Statisticians, analyse and synthesize data from a variety of sources and accordingly draw conclusions

PO3: Develop original thinking for formulating new problems and providing their solutions

PO4: Develop effective and confident Communication skill after completion of the course.

PO5: Identify ethical issues, avoid unethical behaviour such as fabrication, falsification or misrepresentation and misinterpretation of data

PROGRAM SPECIFIC OUTCOMESS (PSOs)

Upon completion of the programme, the students will attain the ability to:

PSO1: Demonstrate an application of statistical tools and techniques in almost all fields which are indispensable for people working in fields like agriculture, business, management, economics, finance insurance, education, biotechnology and medical science, etc.

PSO2: Demonstrate the diverse knowledge of statistical techniques for pursuing higher studies

PSO3: Apply statistical tests judiciously to a variety of data sets to arrive at some valid conclusions.

PSO4: Examine basic statistical issues in a more logical and methodical manner.

PSO5: Strengthen students both computationally and analytically in applying both quantitative and qualitative knowledge to their future careers.

B.Sc. (Honours) Statistics

Note: 1 credit = 15 hours

1. **Theory paper: 6 credits each (5 Theory and 1 Tutorial).**
2. **Tutorial group of each theory paper should have a group size of 8 students.**
3. **Practical paper: 6 credits each (4 Theory and 2 Practical).**
4. **Practical paper will not have tutorials.**

Core Courses (6 Credits Each)

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

Semester I

1. Descriptive Statistics + (Practical)
2. Calculus and Numerical Analysis

Semester II

3. Probability and Probability Distributions + (Practical)
4. Algebra

Semester III

5. Sampling Distributions + (Practical)
6. Survey Sampling and Indian Official Statistics + (Practical)
7. Mathematical Analysis

Semester IV

8. Statistical Inference + (Practical)
9. Linear Models + (Practical)
10. Statistical Quality Control + (Practical)

Semester V

11. Stochastic Process and Queuing Theory + (Practical)
12. Statistical Computing Using C Programming + (Practical)

Semester VI

13. Design of Experiments + (Practical)
14. Multivariate Analysis and Nonparametric Methods + (Practical)

Generic Elective Papers (GE) (6 credits each)

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

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

Semester I

1. Statistical Methods + (Practical)

Semester II

2. Introductory Probability + (Practical)

Semester III

3. Basic Applied Statistics + (Practical)

Semester IV

4. Applied Statistics + (Practical)

Discipline Specific Elective (DSE) (6 credits each)

Discipline Specific Elective (DSE) Course: Elective courses may be 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).

Semester V

DSE-1

1. Operations Research + (Practical)

DSE-2

2. Economic Statistics and Psychological and Educational Statistics + (Practical)

Semester VI

DSE-3

3. Econometrics + (Practical)

DSE-4

4. Demography and Vital Statistics + (Practical)

Skill Enhancement Course (SEC)(2 Credits)

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

Semester III

1. Inter Religious Studies

Semester IV

2. Statistical Data Analysis using Statistical Software Packages

STATISTICS (Hons.) CBCS Syllabus

Sem.	Core Course (14) 6 Credits each	Ability Enhancement Compulsory Course AECC (2) 2 Credits each	Skill Enhancement Course SEC (2) 2 Credits each	Discipline Specific Elective DSE (4) 6 Credits each	Generic Elective GE (4) 6 Credits each
I	STAT CC101: Descriptive Statistics (P) STAT CC102: Calculus and Numerical Analysis	English/ MIL Communication/ Environmental Science			STAT GE101: Statistical Methods (P)
II	STAT CC203: Probability and Probability Distributions (P) STAT CC204: Algebra	English/ MIL Communication/ Environmental Science			STAT GE202: Introduction Probability (P)
III	STAT CC305: Sampling Distributions (P) STAT CC306: Survey Sampling and Indian Official Statistics (P) STAT CC307: Mathematical Analysis		IRS SEC301: Inter Religious Studies (Value based)		STAT GE303: Basic Applied Statistics (P)
IV	STAT CC408: Statistical Inference (P) STAT CC409: Linear Model (P) STAT CC410: Statistical Quality Control (P)		STAT SEC402: Statistical Data Analysis using Statistical Software Packages (Skill based)		STAT GE404: Applied Statistics (P)
V	STAT CC511: Stochastic Process and Queuing Theory (P) STAT CC512: Statistical Computing Using C Programming (P)			STAT DSE501: Operations Research (P). STAT DSE502: Economic Statistics and Psychological and Educational Statistics (P)	
VI	STAT CC613: Design of Experiments (P) STAT CC614: Multivariate Analysis and Nonparametric Methods (P)			STAT DSE603: Econometrics (P) STAT DSE604: Demography and Vital Statistics (P)	

Course Structure for B.Sc. Statistics (Hons.)

<u>Semester – I</u>	<u>Semester – II</u>
STAT CC101: Descriptive Statistics (Practical)	STAT CC203: Probability and Probability Distributions (Practical)
STAT CC102: Calculus and Numerical Analysis	STAT CC204: Algebra
ENG AEC101 : English Communication HIN AEC101: fgUnhO;kdj.kvkSjIEizs"k.k	EVS AEC202 : Environmental Science
STAT GE101: Statistical Methods (Practical)	STAT GE202: Introductory Probability (Practical)
<u>Semester – III</u>	<u>Semester – IV</u>
STAT CC305: Sampling Distributions (Practical)	STAT CC408: Statistical Inference (Practical)
STAT CC306: Survey Sampling and Indian Official Statistics (Practical)	STAT CC409: Linear Models (Practical)
STAT CC307: Mathematical Analysis	STAT CC410: Statistical Quality Control (Practical)
IRS SEC301: Inter Religious Studies	STAT SEC402: Statistical Data Analysis using Statistical Software Packages
STAT GE303: Basic Applied Statistics (Practical)	STAT GE404: Applied Statistics (Practical)
<u>Semester – V</u>	<u>Semester – VI</u>
STAT CC511: Stochastic Process and Queuing Theory (Practical)	STAT CC613: Design of Experiments (Practical)
STAT CC512: Statistical Computing Using C Programming (Practical)	STAT CC614: Multivariate Analysis and Nonparametric Methods (Practical)
STAT DSE501: Operations Research (Practical)	STAT DSE603: Econometrics (Practical)
STAT DSE502: Economic Statistics and Psychological and Educational Statistics (Practical)	STAT DSE604: Demography and Vital Statistics (Practical)

Details of Credits for Courses under B.A., B.Sc., B.Com. Honours

STATISTICS

Semester	Course	Theory	Practical	Tutorial	Total Credits
<u>I. Core Course (14 Papers) – 06 Credits Each</u>					
I	1. Descriptive Statistics (Practical)	4	2	-	6
	2. Calculus and Numerical Analysis	5		1	6
II	3. Probability and Probability Distributions (Practical)	4	2	-	6
	4. Algebra	5	-	1	6
III	5. Sampling Distributions (Practical)	4	2	-	6
	6. Survey Sampling and Indian Official Statistics (Practical)	4	2	-	6
	7. Mathematical Analysis	5	-	1	6
IV	8. Statistical Inference (Practical)	4	2	-	6
	9. Linear Models (Practical)	4	2	-	6
	10. Statistical Quality Control (Practical)	4	2	-	6
V	11. Stochastic Process and Queuing Theory (Practical)	4	2	-	6
	12. Statistical Computing Using C Programming (Practical)	4	2	-	6
VI	13. Design of Experiments(Practical)	4	2	-	6
	14. Multivariate Analysis and Nonparametric Methods (Practical)	4	2	-	6
<u>II. Elective Course – 06 Credits Each</u>					
<u>A. 1. Discipline Specific Elective – DSE (4 Papers)</u>					
V	1. Operations Research (Practical)	4	2	-	6
	2. Economic Statistics and Psychological and Educational Statistics (Practical)	4	2	-	6
VI	1. Econometrics (Practical)	4	2	-	6
	2. Demography and Vital Statistics (Practical)	4	2	-	6
<u>B. 1. Generic Elective / Interdisciplinary (4 Papers)</u>					
I	1. Statistical Methods (Practical)	4	2	-	6
II	2. Introductory Probability (Practical)	4	2	-	6
III	3. Basics of Applied Statistics (Practical)	4	2	-	6
IV	4. Applied Statistics (Practical)	4	2	-	6
<u>III. Ability Enhancement Courses– 02 Credits Each</u>					
<u>1. Ability Enhancement Compulsory (AECC)</u>					
I	English / Hindi Communication	2			2
II	Environmental Science	2			2
<u>II. Skill Enhancement Course (SEC)</u>					
III	1. Inter Religious Studies	2	-	-	2
IV	2. Statistical Data Analysis using Statistical Software Packages	2	-	-	2
TOTAL					140

Institute should evolve a system/policy about ECA / General Interest / Hobby / Sports / NCC / NSS / related courses on its own. *wherever there is practical there will be no tutorial and vice-versa.

Statistics (Honours) Details of CBCS Syllabus

Core Courses (6 Credits Each)

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

SEMESTER – I

STAT CC101 (Descriptive Statistics)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand the statistical data, types of data, tabular and graphical presentation of data, scales of measurement, measures of central tendency, measures of dispersion, moments, Skewness and Kurtosis, Coefficient of variation,

CO2: Comprehend the Correlation (Simple, Multiple and Partial), Rank Correlation, Intra-class correlation etc.

CO3: Apply regression analysis, principle of least squares and fitting of different polynomials and exponential curves.

CO4: Understand the consistency of data and independence of attributes, measures of association of attributes.

STAT CC101: Descriptive Statistics (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: frequency distribution and graphical representation including histogram, ogive and boxplot.	15
2	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, Shephard's corrections.	15
3	Bivariate data: Definition, scatter diagram, Correlation coefficient, partial and multiple correlation (3 variables only), Rank correlation, Correlation ratio, Intra-	15

	class correlation, Simple linear regression, properties of linear regression, principle of least squares and fitting of polynomials and exponential curves.	
4	Theory of Attributes: Notations, dichotomy, classes and class frequencies, consistency of data and its conditions, independence of attributes, criterion of independence. Association of attributes, Yule's coefficient of association, coefficient of colligation.	15
	Practical work: Problems based on central tendency, Problems based on dispersion, Karl Pearson's correlation coefficient, Fitting of polynomials, Exponential curves, Problems based on partial and multiple correlations, association of attributes.	30
	TOTAL	90

Reading List:

1. Craig. Mckean Hogg: Introduction to Mathematical Statistics, 6thEdn.
2. Miller, Irwin and Miller, Marylees (2006): Jhon E. Freund's Mathematical Statistics with Applications, (7thEdn.) 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.
4. Gupta S.C. and Kapoor V.K. (2013): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
5. Tukey John W.: Kendall' Advanced Theory of Statistics, 6th Edn., Alan Surat and Keith ORD.

SEMESTER – I

STAT CC 102 (Calculus)

Course Outcomes:

After Completion of the course, student will be able to :-

CO1: Understand the fundamental concepts of functions with several variables, its derivatives in partial form with other important related concepts, their applications in maxima - minima problems.

CO2: Apply the principles of integral to solve a variety of practical problems in science and different fields.

CO3: Recognize Ordinary Differential Equations (ODEs) and system of ODEs concepts that are encountered in the real world, understand and able to communicate the underlying mathematics involved helping another person gain insight into the situation.

CO4: Distinguish between linear, nonlinear, partial and ordinary differential equations and use correct mathematical terminology, notation, and symbolic processes in order to engage in work, study and conversation on topics involving differential equations with colleagues in the field of mathematics and sciences.

STAT CC102: Calculus		
PWC (Theory: 5 Credits + Tutorial: 1 Credits)		
Units	Topics to be covered	No. of Hours
1	Differential and Integral Calculus: Function and its limit, continuous functions, properties of continuous functions, Total differentiation and partial differentiation. Indeterminate forms: L-Hopital'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. Review of integration and definite integral. Beta and Gamma functions: properties and relationship between them.	20
2	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.	20

3	Partial Differential Equations: 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. Homogeneous linear partial differential equations with constant coefficients.	15
4	Numerical Analysis: Factorial, finite differences and interpolation. Operators and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling's interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Weddle's rule.	20
	Tutorial	15
	TOTAL	90

Reading List:

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. Ltd., New Delhi (2nd Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
5. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
6. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
7. Sastry, S.S. (2012): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.

SEMESTER – II

STAT CC203 (Probability and Probability Distributions)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand random experiments, Algebra of sets, sample space, algebra of events, definition of Probability, some theorems on probability, Bayes' theorem and its applications.

CO2: Know random variables, p.m.f., p.d.f., distribution function for one dimensional and two dimensional random variables and its properties, transformation of one-dimensional and two-dimensional random variables.

CO3: Know about mathematical expectation and its properties, moment generating function, Cumulant generating function, characteristic function and probability generating function, uniqueness and inversion theorems, Conditional expectations and Conditional variance.

CO4: Understand Standard Probability Distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, multinomial, normal, uniform, gamma, beta, exponential, Cauchy and bivariate normal distribution.

STAT CC203: Probability and Probability Distributions (Practicals)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Probability: Introduction, random experiments, Sets and elements of sets, Operations on sets, Algebra of sets, sample space, events and algebra of events, Definition of Probability – classical, statistical and axiomatic. Law of addition and multiplication, Conditional Probability, independent events, Bayes' theorem and its applications.	12
2	Random Variables: discrete and continuous random variables, p.m.f., p.d.f., distribution function and its properties, 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, Distribution function	15

	of two-dimensional random variables, transformation of one-dimensional and two-dimensional random variables with illustrations	
3	Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Addition and multiplication theorem of expectation. Moments and Cumulants, moment generating function, Cumulant generating function, characteristic function and probability generating function. Uniqueness and inversion theorems (without proof) along with applications, Conditional expectations and Conditional variance.	15
4	Standard Probability Distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, multinomial, normal, uniform, gamma, beta, exponential and Cauchy along with their properties and limiting/approximation cases, Bivariate Normal Distribution.	18
	Practical work: Fitting of binomial, Poisson distributions for given value of λ , Negative-binomial, Normal Distribution. Application based on different Distribution	30
	TOTAL	90

Reading List:

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.
4. Bhat, B.R. (2015): Modern Probability Theory, New Age International (P) Limited Publishers, New Delhi.

SEMESTER – II

STAT CC 204 (Algebra)

Course Outcomes:

After Completion of the course, student will be able to :-

CO1: Develop knowledge of basic concepts of the linear algebra.

CO2: Understand all the concepts of linear algebra and matrices.

CO3: Linear Algebra plays an important role to solve problem in applied mathematics.

CO4: Apply the methods taught in Problem arising out in further studies.

STAT CC204: Algebra		
PWC (Theory 5 Credits + Tutorial: 1 Credits)		
Units	Topics to be covered	No. of Hours
1	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.	20
2	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 of a matrix and related properties.	20
3	Determinant 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, 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 by adjoint and identity matrix.	20
4	Rank of Matrix: Row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations). Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem.	15
	Tutorial	15
	TOTAL	90

Reading List:

1. Lay David C. (2000): Linear Algebra and its Applications, Addison Wesley.
2. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition, 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 (1973): Metric Spaces, Narosa Publishing House, New Delhi.
5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International.
6. Gupta S.C. (2008): An Introduction to Matrices (Reprint). Sultan Chand & Sons.
7. Artin M. (1994): Algebra. Prentice Hall of India.
8. Datta K.B. (2002): Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
9. Hadley G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
10. Searle S.R. (1982): Matrix Algebra Useful for Statistics. John Wiley & Sons.

SEMESTER – III

STAT CC305 (Sampling Distribution)

Course Outcomes:

After Completion of the course, student will be able to :-

CO1: Understand the basic concepts of statistics and parameters.

CO2: Understand the distribution of sample mean, median and range,

CO3: Understand the distribution of order statistics, law of large numbers and central limit theorem.

CO4: Understand the derivation of various exact sampling distributions like t, F and chi-square.

STAT CC305: Sampling Distributions (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebychev's inequality, W.L.L.N. De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapounoff Theorem (without proof).	17
2	Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and s th order statistics, distribution of sample median and sample range. 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.	16
3	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.	12
4	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.,	15

	nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Relationship between t, F and χ^2 distributions.	
	Practical work: 1. Chebychev's inequality, 2. Weak law of large number, 3. Central limit theorem, 4. Order Statistic	30
	TOTAL	90

Reading List:

1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
2. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
4. 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.
5. Gupta, S.C. and Kapoor, V.K. (2013): Fundamentals of Mathematical Statistics, Sultan Chand& Sons, New Delhi.

SEMESTER – III

STAT CC306 (Survey Sampling and Indian Official Statistics)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand the principal steps in sample survey, basic principle of sample survey, errors in sampling, complete enumeration versus sampling, simple random sampling with and without replacement, procedure of selecting a sample and determination of sample size.

CO2: Know the concept of stratified random sampling, proportional and optimum allocations and their comparisons with SRS, practical difficulties in allocation, estimation of gain in precision, systematic sampling.

CO3: Know about ratio, product and regression method of estimation, cluster sampling for equal clusters, two-stage sampling.

CO4: Know about Official Statistical System in India through MoSPI, CSO, NSSO, National Statistical Commission and Government of India's Principal publications.

STAT CC306: Sample Survey and Indian Official Statistics (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Concept of population and sample, principal steps in sample survey, basic principle of sample survey, sampling and non-sampling errors, complete enumeration versus sampling, Types of sampling: non-probability and probability sampling, 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.	15
2	Stratified Random Sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparisons 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 = nxk).	15

3	Introduction to Ratio, Product and Regression Method of Estimation and Cluster Sampling: Introduction to Ratio, Product and regression methods of estimation, Cluster sampling (equal clusters only), estimation of population mean and its variances, relative efficiency of cluster sampling over SRS. Concept of sub sampling, two-stage sampling with equal first stage units	20
4	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.	10
	Practical work: 1. To select a SRS with and without replacement. 2. For a population, estimate population mean, population mean square and population variance. Enumerate all possible samples of given size 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. Systematic sampling.	30
	TOTAL	90

Reading List:

1. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. and Asok, C.(1984). Sampling Theories of Surveys with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1967): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Guide to Current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
6. Mukhopadhyay, P. Sampling Methods; Pearson Publication.
7. <http://mospi.nic.in/>

SEMESTER – III

STAT CC 307 (Mathematical Analysis)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand over all concepts of algebraic structures.

CO2: Apply Mathematical Analysis plays an important role in solving problem in pure mathematics.

CO3: Real analysis is important part of pure mathematics. Stress is laid on development of analytical abilities of the students.

CO4: Numerical Analysis is a topic of the day and here students is taught some programming methods and solve linear and non-linear equation and analyse & evaluate the accuracy.

STAT CC307: Mathematical Analysis		
PWC (Theory: 5 Credits + Tutorial: 1 Credit)		
Units	Topics to be covered	No. of Hours
1	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.	20
2	Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n^{th} 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' Hopital's rule.	18
3	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 $\sin x$, $\cos x$, $\log(1+x)$, e^x .	20
4	Numerical analysis: Inverse interpolation, solution of algebraic and transcendental equations, Difference equation with constant coefficient, Simple cases of numerical solutions of differential equation by Euler and modified Euler methods.	17
	Tutorial	15
	TOTAL	90

Reading List:

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

SEMESTER – IV

STAT CC408 (Statistical Inference)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Use various methods of estimation such as method of moments and method of maximum likelihood etc. to find an estimate for unknown population parameter

CO2: Understand the concepts of testing of hypothesis, critical region and related theorems with applications as well as decision problems.

CO3: Perform various tests of significance for mean, proportion etc.

CO4: Develop knowledge of sequential analysis and sequential probability ratio test.

STAT CC408: Statistical Inference (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Estimation: Concept of estimation, unbiasedness, sufficiency, consistency and efficiency. Fisher-Neyman Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators.	17
2	Methods of Estimation: Method of moments, method of maximum likelihood, method of minimum Chi-square, basic idea of Baye's estimators.	10
3	Principles of hypothesis testing: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, randomized and non randomized tests, most powerful test, uniformly most powerful test, Neyman Pearson Lemma and its applications to construct most powerful tests.	16
4	Sequential Analysis: Sequential probability ratio test (SPRT). Determination of A and B in practice. Operating characteristics (OC) and average sample number (ASN) functions (without proof), examples based on normal, Poisson, binomial and exponential distributions. Test of significance: large sample tests, tests based on t, F and χ^2 distributions, tests for goodness of fit and independence of attributes, interval estimation.	17

	<p>Practical Work:</p> <p>1. Large sample test for single population mean, difference between two population mean, single population proportion and difference between two population proportions, 2. Small sample test for single mean, difference between two means (independent), paired t-test and test for correlation, 3. F-test for the equality of two population variances, 4. Chi-Square test for testing population variance against a specified value, testing of goodness of fit, testing for independence of attributes, 5. Simple random sample with the help of table of random numbers, 6. Simple random sample with the inverse transform method (Bernoulli, Binomial, Poisson, Normal, exponential), 7. The likelihood and log-likelihood curve for Binomial, Poisson and Normal distribution, 8. Determination of Type I and Type II errors, 9. Most powerful critical region (NP Lemma), 10. Uniformly most powerful critical region, 11. Unbiased critical region, 12. Power curves</p>	30
	TOTAL	90

Reading List:

1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
2. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
3. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
4. Mood A.M, Graybill F.A. and Boes D.C.: Introduction to the Theory of Statistics, McGraw Hill.
5. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
6. Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Iowa State University Press.
7. Casella. Berger and Berger. Roger. L (2012): Statistical Inference (2nd edition).
8. Sinha S.K.: Bayesian Statistics, Published by Estern wiley.
9. Hogg .V Robort, Mckean J. and Craig. T. Allean: Introduction to Mathematical Statistics (7th Edition), Pearson.

SEMESTER – IV

STAT CC409 (Linear Models)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Predict the unknown value of dependent variable for known value of independent variable.

CO2: Use the techniques of analysis of for testing the dependence of a quantitative variable on a qualitative variable.

CO3: Use analysis of covariance (one way) technique for testing the dependence of a quantitative variable on a qualitative variable when we have given a quantitative auxiliary (independent) variable.

CO4: Overcome the problems such as multicollinearity and heteroscedasticity which arises due to the violation of assumptions of a linear model.

STAT CC409: Linear Models (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
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.	16
2	Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, parabolic regression model, Concept of model matrix and its use in estimation. R^2 and adjusted R^2 .	17
3	Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance for one way and two way classified data and Analysis of covariance in one-way classified data for fixed effect models.	15
4	Model Checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity.	12
	Practical Work: 1. Estimability when X is a full rank matrix and not a full rank matrix, 2. Simple Linear Regression, 3. Multiple Regression, 4. Tests for Linear Hypothesis, 5. Bias in regression estimates, 6. Lack of fit, 7. Orthogonal Polynomials, 8. Analysis of Variance of one way and two-	30

	way classified data, 9. Analysis of Covariance of a one way classified data.	
	TOTAL	90

Reading List:

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. Gutpa, S.C. and Kapoor, V.K. (2013). Fundamental of Applied Statistics, Sultan Chand and Sons, New Delhi.
5. Kutner Michael H., Applied Linear Statistical Model (5th Edition).
6. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012): Introduction to linear regression analysis, 5th Edition, Wiley India Pvt. Ltd.

SEMESTER – IV

STAT CC410 (Statistical Quality Control)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Know the dimension of quality, history of quality, ISO quality standards, quality registration, causes of variation, seven tools of statistical process control and basis of 3σ control charts.

CO2: Aware about control charts for variables and attributes, comparison between control charts for variables and attributes. Analysis of patterns on control chart and estimation of process capability.

CO3: Understand the acceptance sampling plan, single and double sampling plans and their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

CO4: Understand the concept of six-sigma, lean manufacturing and total quality management (TQM).

STAT CC410: Statistical Quality Control (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Quality: Definition, dimension of quality, historical perspective of quality control and improvements starting from World War II. Introduction to ISO quality standards, Quality registration. Statistical Process Control – Seven tools of SPC, chance and assignable Causes of variation, Statistical Control Charts – Construction and Statistical basis of 3σ Control charts.	15
2	Control Charts for Variables: X-bar & R-chart, X-bar & s-chart, Control charts for attributes: np-chart, p-chart and c-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.	17
3	Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plans and their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.	13
4	Introduction to six-sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM).	15

	Practical work: 1. Construction and interpretation of statistical control charts X-bar & R-chart, X-bar & s-chart, np-chart, p-chart, c-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.	30
	TOTAL	90

Reading List:

1. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.
3. Montgomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
4. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
5. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.
6. Amitava Mitra (2016): Fundamentals of Quality Control and Improvement, 4th Edition, Wiley India Pvt. Ltd.

SEMESTER – V

STAT CC511 (Stochastic Processes and Queuing Theory)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Predict the future results in terms of probability for the given stochastic models.

CO2: Compute the probability of recurrence of an event.

CO3: Compute the expected duration of game.

CO4: Compute waiting time distributions for various queuing models

STAT CC511: Stochastic Process and Queuing Theory (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Probability Distributions: Generating functions, probability generating function. Stochastic Process: Introduction, Stationary Process.	15
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.	15
3	Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process (homogeneous), pure death process.	15
4	Gambler's Ruin Problem: Classical ruin problem, expected duration of the game Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).	15
	Practical work: 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	30

	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 behavior 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.	
	TOTAL	90

Reading List:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Medhi, J. (2002): Stochastic processes, 2nd edn revised reprint, New Age International publishers.
4. Sheldon M. Ross. (2008): Stochastic processes, 3rd edition Reprint, Wiley India Pvt. Ltd.
5. Bhat, B. R. (2000): Stochastic models: analysis and applications, New Age International publishers.

SEMESTER – V

STAT CC 512 (Statistical Computing using C programming)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Develop various basic concepts, features and components related to C programming language.

CO2: Define data types and use them in simple data processing applications.

CO3: Design and develop C programs, analyses and interpret the concept of control statements, array, pointer, function, structure, declaration, initialisation, operators and their uses.

CO4: Develop their basic programming skill using ‘PYTHON’ in data analysis.

STAT CC512: Statistical Computing using C Programming (Practical) PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Fundamentals of computers, Memory (RAM, ROM, EPROM, EEPROM), Number System, Construction of flow chart, various types of Gates. History and importance of C, Tokens, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants. Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Library functions, managing input and output operations.	15
2	Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional (?) operator. Looping in C for, nested for, while, do...while, jumps in and out of loops. Arrays: Declaration and initialization of one-dimensional and two-dimensional arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal.	15
3	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. Recursion function. Passing arrays to functions. Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers	15

4	Structure: Definition and declaring, initialization, accessing structure members. Introduction to Python Programming Language, Evolution of Python, Python as a programming language, Advantages of using python, Coding environment-python console and IDE and popular python editor (Jupyter/Spyder).	15
	Practical / Lab Work (Using C Programming Language) 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. Variance and coefficient of variation of a Grouped Frequency Data 6. Preparing a frequency table 7. Value of $n!$ using recursion 8. Matrix addition, subtraction, multiplication Transpose and Trace 9. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit.	30
	TOTAL	90

Reading List:

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.
4. Venugopal K. R and Prasad. R. Sudeep: Mastering C (2nd Edition), McGraw Hill.
5. Kamthane. A.N and Kamthane. A. A.: Programming in C (3rd Edition), Pearson.
6. Kanetkar, Yashwant: Let Us C (14th Edition), BPB Publications.

STAT CC 613 (Design of Experiments)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Apply the concepts of basic designs like CRD, RBD & LSD in agricultural and industrial design of experiments.

CO2: Draw the inferences about the dependency of a variable on an attribute.

CO3: Apply the knowledge of incomplete block design in experiments when block size is less than the number of treatments under study.

CO4: Implement factorial experiment to analyse the effects of varying levels of two or more factors simultaneously.

STAT CC613: Design of Experiments (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Experimental Designs and Basic Design: 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 single missing observation.	17
2	Incomplete Block Design: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Intra block analysis of BIBD	16
3	Factorial experiments: advantages, notations and concepts, 2^2 , $2^3 \dots 2^n$ factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 4$) and 3^2 . Factorial experiments in a single replicate.	15
4	Fractional Factorial Experiment: Construction of one-half and one-quarter fractions of 2^n ($n \leq 4$) factorial experiments.	12
	Practical work: 1. Analysis of a CRD, 2. Analysis of an RBD, 3. Analysis of LSD, 4. Analysis of an RBD with one missing observation, 5 Efficiency Comparison. 6. Intra Block analysis of a BIBD, 7. Analysis of 2^2 and 2^3	30

	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 experiment in 2 blocks, 10. Analysis of a completely confounded two level factorial experiment in 4 blocks, 11. Analysis of a partially confounded two level factorial experiment, 12. Analysis of a fraction of 2^n factorial design.	
	TOTAL	90

Reading List:

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. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
4. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
5. Mukhopadhyay. P (2011): Applied Statistics, 2nd Edition revised reprint, Books and Allied (P) Ltd.
6. Morris Max. D: Design of Experiment: An introduction Based on Linear Models, CRC Press.

SEMESTER – VI

STAT CC614 (Multivariate Analysis and Non-parametric Methods)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand bivariate normal distribution, bivariate and multivariate data, random vector, p.m.f., p.d.f., distribution function, mean vector and dispersion matrix, marginal and conditional distributions.

CO2: Know the concept of multivariate normal distribution and its properties, sampling distribution of mean vector, concept of multiple and partial correlation coefficient and their properties.

CO3: Know the applications of multivariate analysis in discriminant analysis, principal components analysis and factor analysis.

CO4: Know about non-parametric test which includes the test of randomness, empirical distribution function, Kolmogorov Smirnov test, sign test and Wilcoxon-Mann-Whitney test, median test and Wilcoxon-Mann-Whitney test.

STAT CC614: Multivariate Analysis and Non Parametric Methods (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
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.	15
2	Multivariate normal distribution and its properties. Sampling distribution of mean vector. Concept of Multiple and partial correlation coefficient and their properties.	15
3	Applications of Multivariate Analysis: Discriminant Analysis, Principal Components Analysis and Factor Analysis.	15
4	Non-parametric test: 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, Median test, Wilcoxon-Mann-Whitney test.	15

	Practical Work: 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. Kolmogrov Smirnov test for one sample, 10. Sign test: one sample, two samples, large samples, 11. Median test, 12. Wilcoxon-Mann-Whitney U-test.	30
	TOTAL	90

Reading List:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley.
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1st Edn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Statistical Analysis, 6th Edn., Pearson & Prentice Hall.
5. Rencher, Alvin C, (2002): Methods of Multivariate Analysis, 2nd Edition, John Wiley & Sons, Inc. Publication.
6. Mukhopadhyay, P.: Mathematical Statistics.
7. Gibbons, J. D. and Chakraborty, S. (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
8. Daniel, Wayne W., Non Parametric Statistics.

Generic Elective Papers (GE) (6 Credits Each)

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

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

SEMESTER – I

STAT GE 101 (Statistical Methods)

Course Outcomes:

After Completion of the course, student will be able to:-

After Completion of the course student would be able to:-

CO1: Understand the concept of descriptive Statistics.

CO2: Understand the statistical data, types of data, tabular and graphical presentation of data, scales of measurement, measures of central tendency, measures of dispersion, moments, Skewness and Kurtosis, Coefficient of variation.

CO3: Understand the Correlation (Simple, Multiple and Partial), Rank Correlation, Intra-class correlation and regression analysis, principle of least squares and fitting of different polynomials and exponential curves.

CO4: Understand the consistency of data and independence of attributes, measures of association of attributes

<u>STAT GE101: Statistical Methods</u>		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
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. Presentation: Frequency distribution and graph including histogram, ogives and Boxplot.	15
2	Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.	15
3	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.	15

4	Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.	15
	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, Regression lines. 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	30
	TOTAL	90

Reading List:

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.
4. Gupta, S.C. and Kapoor, V.K. (2013): Fundamentals of Mathematical Statistics, Sultan chand& Sons, New Delhi.
5. Agarwal B.L. (2013): Basic Statistics, New age International Publishers, New Delhi.

SEMESTER – II

STAT GE 202 (Introduction Probability)

Course Outcomes:

After Completion of the course, student will be able to:-

- CO1:** Understand the concept of probability and the law related to it.
- CO2:** Comprehend random experiments, sample space, events, various concepts associated with theory of probability, random variables, p.m.f and p.d.f. for univariate random variables, distribution function.
- CO3:** Understand the concepts of mathematical expectations, variance, moments and m.g.f..
- CO4:** Apply standard probability distributions for discrete and continuous random variables.

STAT GE202: Introductory Probability		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Probability: Introduction, random experiments, Sets and elements of sets, Operations on sets, Algebra of sets, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic, laws of addition and multiplication, Conditional Probability independent events. Bayes' theorem and its applications.	15
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.	15
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.).	15
4	Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential.	15
	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. Application based problems using normal distribution 10. Fitting of normal distribution when parameters are given 11. Fitting of normal distribution when parameters are not given	30
	TOTAL	90

Reading List:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Edition, Pearson Education, New Delhi.

2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. Bhat, B.R. (2015): Modern Probability Theory, New Age International (P) Limited Publishers, New Delhi.

SEMESTER – III

STAT GE303 Basic Applied Statistics

Course Outcomes:

After Completion of the course, student will be able to:-

- CO1:** Understand the concepts of testing of hypothesis, test of significance for mean, proportion using parametric and non-parametric tests.
- CO2:** Analyse point and interval estimates for an unknown parameter
- CO3:** Use the techniques of analysis of variance for testing the dependency of a quantitative variable on a qualitative variable.
- CO4:** Understand the concepts and principle of design of experiment also with planning of a suitable design to conduct an experiment under different conditions.

STAT GE303: Basic Applied Statistics (Practical) PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Estimation of population mean, The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). Confidence intervals for the parameters of a normal distribution.	15
2	Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-Square test, Tests for the significance of correlation coefficient.	15
3	Simple Nonparametric test: Sign test for one sample and two sample, median, Mann-Whitney-Wilcoxon test.	15
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.	15
	Practical Work: 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	30

	goodness-of-fit. 7. Test for correlation coefficient. 8. Sign test for median. 9. Sign test 10. Mann-Whitney-Wilcoxon 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.	
	TOTAL	90

Reading List:

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. (1986): Design and Analysis of Experiments, Wiley Eastern Limited.
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.

STAT GE 404 (Applied Statistics)

Course Outcomes:

After Completion of the course, student will be able to:-

- CO1:** Know components of time series, decomposition of time series, measurement of trend by different methods, measurement of seasonal variations by ratio to trend method.
- CO2:** Understand about Index numbers, criteria for a good index number, different types of index numbers, construction of index numbers, consumer price index number, uses and limitations of index numbers.
- CO3:** Perceive the concept of statistical quality control, importance of statistical methods in industrial research and practice, determination of tolerance limits, causes of variations in quality, general theory of control charts, process and product control, Control charts for variables and attributes.
- CO4:** Grasp the demographic methods, measurement of rates and ratios of vital events, measurement of CDR, SDR, IMR, SDR, life tables, measurement of CBR, GFR and TFR, measurement of GRR and NRR.

STAT GE404: Applied Statistics (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
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.	15
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.	15
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.	15
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:	15

	definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR and TFR. Measurement of population growth: GRR, NRR.	
	Practical Work: 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. 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.	30
	TOTAL	90

Reading List:

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons
3. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
4. Phathak, K. B. and Ram, F.: Techniques of Demographic Analysis, Himalaya Publishing House.

Ability Enhancement Compulsory Courses (AECC)

English (2 Credits)

“AECC” courses are the courses based upon the content that leads to Knowledge enhancement;

i. English/Hindi communication, ii. Environmental Science

Semester – I

ENG AEC101 : English Communication

Course Outcomes:

After completion of the course, the students will be able to:

CO1: Communicate effectively using the techniques in the area of spoken as well as written communication.

CO2: Hone their LSRW skills within their communication.

CO3: Design and answer job interview questions

CO4: Demonstrate the ability to craft professional messages that are clear yet courteous.

<u>ENG AEC101</u> : English Communication		
PWC (Theory :2 credits)		
Units	Topics to be covered	No. of hours
1	<u>Communication</u> (a) Definition of Communication (b) Stages of Communication (c) Barriers of Communication (d) Verbal and Non-verbal Communication (e) Skills of Communication – Listening, Reading, Writing, Speaking	5
2	<u>Listening Skill</u> (a) Meaning and Importance of Listening (b) Principles of Good listening	5

3	<u>Writing Skills</u> (a) Notice, Agenda, Minutes of the meeting (b) Report writing, Circulars (c) Writing Resume (d) Building vocabulary	15
4	<u>Speaking Skill</u> (a) Interview (b) Meeting (c) Situational Conversation	5
	TOTAL	30

Suggested Readings:

1. Scot, O.; Contemporary *Business Communication*. Biztantra, New Delhi.
2. Lesikar, R.V. & Flatley, M.E.; *Basic Business Communication Skills for Empowering the Internet Generation*, Tata McGraw Hill Publishing Company Ltd. New Delhi.
3. Ludlow, R. & Panton, F.; *The Essence of Effective Communications*, Prentice Hall Of India Pvt. Ltd., New Delhi.
4. R. C. Bhatia, *Business Communication*, Ane Books Pvt Ltd, New Delhi.

SEMESTER I

HINAECC101 – Hindi Grammar and Semantics

- ifj.kke & 1- fofHkUu izfr;ksxh ijh{kkvksa ds fy, rS;kj djukA
2- IEIzs"k.k&{kerk dh o`f) djukA
3- dk;kZy;h&i= ys[ku dh {kerk fodflr djuk A
4- fgUnh ds O;kdjf.kd ,oa IS)kafrd Lo:i dh tkudkjh gkfly djukA

HIN AEC101		
हिन्दी व्याकरण और सम्प्रेषण		
PWC (Theory: 2 credits)		
Unit	Topics to be covered	No. of hours
1	हिन्दी व्याकरण और रचना : संज्ञा, सर्वनाम, विशेषण, क्रिया, अव्यय, उपसर्ग, प्रत्यय, समास, सन्धि, पर्यायवाची शब्द, विलोम शब्द, अनेक शब्दों के लिए एक शब्द, मुहावरे एवं लोकोक्तियाँ, पल्लवन, संक्षेपण, शब्द शुद्धि, वाक्य शुद्धि, विविध प्रकार के पत्र-लेखन	15
2	सम्प्रेषण : भाषिक सम्प्रेषण : स्वरूप और सिद्धांत, सम्प्रेषण की अवधारणा और महत्व, सम्प्रेषण की प्रक्रिया, सम्प्रेषण के विभिन्न मॉडल, सम्प्रेषण की चुनौतियाँ	05
3	सम्प्रेषण के प्रकार : मौखिक और लिखित, वैयक्तिक और सामाजिक, व्यावसायिक, भ्रामक सम्प्रेषण, सम्प्रेषण बाधाएँ और रणनीति	05
4	सम्प्रेषण के माध्यम : एकालाप, संवाद, सामूहिक चर्चा, प्रभावी सम्प्रेषण	05
	Total :	30

SEMESTER-II

EVS AEC 202 : Environmental Science (2 Credits)

Course Outcomes:

After completion of the course, the students will be able to:

- CO1:** Understand multidisciplinary nature of environmental studies.
- CO2:** Understand the concept and types of natural resources and environmental pollution.
- CO3:** Evaluate the anomalies created due to haphazard population growth and its impact on environment.
- CO4:** Understand about the organizations, conventions and legislations working on mitigation of environmental issues.

<u>EVS AEC 202 : Environmental Science (2 Credits)</u>		
PWC		
Unit	Topics to be covered	No. of hours
1	(a) Multidisciplinary Nature of Environmental Studies: Definition, Scope and Importance. (b) Concept of Ecosystem: - Components, Elementary Idea of Major Ecosystem:	07
2	(a) Natural Resources : Land, Water, Forest And Mineral Resources : Introduction; Earth's Resources and Man; Renewable and Non-Renewable Resources ; Natural Resources and Associated Problems ; Non-Renewable Resources ; Renewable Resources ; Non-Renewable Energy; Renewable Energy, Conservation of Natural Resources (b) Biodiversity and its conservation: Hotspots and threats to Biodiversity : Biodiversity ; Definition ; Keystone Species ; Conservation of Biodiversity ; Methods For The Conservation of Wildlife ; Hot Spots ; Types of Biodiversity ; Genetic, Species and Ecosystem Diversity, Threats to Biodiversity ; Endangered And	10

	<p>Endemic Species ; Conservation of Biodiversity: In Situ And Ex-Situ ; Wildlife Sanctuaries and National Parks of India ; The Need for An Integrated Protected Area System (IPAS) ;; Beej Bachao Andolan ; List of Biosphere Reserves in India ; Tiger Reserves in India.</p>	
3	<p>Environmental Pollution:</p> <p>(a) Causes, Effects, and Control Measures ; Types and sources of Pollution.</p> <p>(i) Air Pollution ; Sources of air pollution and its impact on human health.</p> <p>(ii) Water Pollution and contamination: Introduction, Types and sources; Classification of Water Pollutants. Impact on human health</p> <p>(iii) Soil Pollution : Introduction: Contaminants and Degradation; Impact on human health.</p> <p>(iv) Noise Pollution: Effects of Noise Pollution on Physical Health; Permitted Noise Levels; Noise-Control Techniques. Impact on human health.</p> <p>(b) Public Awareness about Greenhouse Effects; Acid Rain; Effects; Ozone Layer Depletion, Ganga Action Plan (GAP); Chipko Movement; Chernobyl disaster; Bhopal Gas Tragedy.</p> <p>(c) Environment and Human Health: Outcome of Unhygienic Environmental Conditions</p>	05
4	<p>Human Population and Environment and Important Organizations:</p> <p>(a) Population Growth, Variation Among Nations : Global Population Growth ; Population Explosion – Family Welfare Program ; Urban Poverty and The Environment ; Environment and Human Health ; Environmental Health ; Examples of</p>	08

	<p>Linkages ; Definition of Health Impact Assessment (HIA) by WHO ; Climate and Health ; Infectious Diseases; Water borne and water related diseases, Mitigation Strategies to control adverse health impact, Role of Information Technology in Environment and Human Health.</p> <p>(b) Important Organizations : IUCN ; WWF ; BNHS ; PETA; Important Dates and Years; Some Important Environmental Conventions ; Atmospheric conventions ; Biodiversity conventions ; Land conventions ; Hazardous wastes ; Some important Acts and Notifications in India ; Environment Action Programme – India (EAP) ; Environment Protection Act ; Penalties ; Air (Prevention and Control of Pollution) Act 1981 ; Penalties ; Water (Prevention and control of Pollution) Act ; Penalties ; Wildlife Protection Act ; Penalties ; Forest Conservation Act ; Penalties ; Issues involved in enforcement of environmental legislation.</p>	
	TOTAL	30

Reading List :

1. Chandna R. C., 2002: *Environmental Geography*, Kalyani Publications, Ludhiana.
2. UNEP, 2007: *Global Environment Outlook: GEO4: Environment for Development*, United Nations Environment Programme
3. Odum, E. P. et al, 2005: *Fundamentals of Ecology*, Ceneage Learning India.
4. Singh S., 1997: *Environmental Geography*, Prayag Pustak Bhawan. Allahabad.
5. Baskar Sushmita and Baskar R. 2007 : *Environmental studies for Undergraduate Courses*, Unicorn Books, Bangalore

Discipline Specific Elective (DSE) (6 Credits Each)

Discipline Specific Elective (DSE) Course: Elective courses may be 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).

SEMESTER – V

STAT DSE (501 Operations Research)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Develop the knowledge of formulation of practical problems using the linear programming method and its extensions.

CO2: Understand the theoretical basics of different computational algorithms used in solving linear programming and related problems.

CO3: Apply the knowledge of game theory concepts to articulate real-world decision situations for identifying, analysing and practicing strategic decisions to counter the consequences.

CO4: Develop the comprehensive study of various application area of inventory models through case studies and relevant examples.

<u>STAT DSE501: Operations Research (Practical)</u>		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
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-primal relationship.	15
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.	15

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, dijkstra algorithm and minimal spanning tree problem.	15
4	Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages.	15
	Practical Work: 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. Post-optimality a. Addition of constraint b. Change in requirement vector c. Addition of new activity d. Change in cost vector 4. Allocation problem using Transportation model 5. Allocation problem using Assignment model 6. To find optimal inventory policy for EOQ models and its variations 7. To solve all-units quantity discounts model 8. Problems based on game matrix a. Graphical solution to $m \times 2 / 2 \times n$ rectangular game b. Mixed strategy.	30
	TOTAL	90

Reading List:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, 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.
5. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
6. Bronson. R. and Naadimuthu. G: Operations Research: Schaum's outlines (2nd edition).
7. Shridhara Bhat, K: Operations Research, Himalaya Publishing House.
8. Salimath, C. and Parashar, B.: Operations Research, Models and Methods, Universities Press.

SEMESTER – V

STAT DSE502 (Economic Statistics and Psychological and Educational Statistics)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand the concept of times series data and its application in various fields, components of a times series, decomposition of time series, measurement of trend by different methods, detrending, effect of elimination of trend on other components of the time series.

CO2: Know about the seasonal component of time series and its estimation by different methods, deseasonalisation of data, cyclic component, random component and forecasting.

CO3: Recognize the concept of index numbers, construction of index numbers, different types of index numbers, chain index numbers, conversion of fixed based to chain based index numbers, criteria of a good index number and Consumer price index numbers.

CO4: Understand the application of statistical methods in Psychology and Education, scaling, z-scores, standard score, normalised score, T- score, reliability and validity of scores, methods of comparison between reliability and validity.

STAT DSE502: Economic Statistics and Psychological and Educational Statistics (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Introduction to times series data, application of time series in various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve and growth curves, method of moving averages. Detrending. Effect of elimination of trend on other components of the time series	15
2	Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method, Deseasonalization of data. Cyclic Component: Harmonic Analysis. Random Component: Variate difference method. Forecasting: Exponential smoothing methods, Short term forecasting methods.	15

3	Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Marshall-Edgeworth and Fisher's. Average of price relatives, weighted average of relatives, Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Criteria of a good index number, Consumer price index numbers.	15
4	Psychological and Educational Scores: The problem of measurement of Psychological and Educational Traits, Scaling, Z-scores, standard score, Normalised score, T- score. Reliability and Validity of Scores: Validity of test scores, Index of reliability, Methods of Comparison between Reliability and Validity.	15
	Practical Work: 1. Fitting and plotting of modified exponential curve, 2. Fitting and plotting of Gompertz curve, 3. Fitting and plotting of logistic curve, 4. Fitting of trend by Moving Average Method, 5. Measurement of Seasonal indices Ratio-to-Trend method, 6. Measurement of Seasonal indices Ratio-to-Moving Average method, 7. Measurement of seasonal indices Link Relative method, 8. Calculation of variance of random component by variate difference method, 9. Forecasting by exponential smoothing, 10. Forecasting by short term forecasting methods, 11. Calculate price and quantity index numbers using simple and weighted average of price relatives, 12. To calculate the Chain Base index numbers, 13. To calculate consumer price index number.	30
	TOTAL	90

Reading List:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series – An Introduction, Chapman & Hall.
3. Mukhopadhyay, P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied.
4. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition), Pearson Education, Asia.
5. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
6. Gutpa, S. C. and Kapoor, V. K. (2013): Fundamental of Applied Statistics, Sultan Chand and Sons, New Delhi.

SEMESTER – VI

STAT DSE603 (Econometrics)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Understand the Fundamental concept of econometrics.

CO2: Develop knowledge of Specification of the model.

CO3: Develop Knowledge on Multiple linear regression.

CO4: Apply Multicollinearity, heteroscedasticity, autocorrelation and autoregressive with their required testing procedure and remedies to overcome these problems

STAT DSE603: Econometrics (Practical)		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Introduction: Nature of econometrics, role of econometrics, model building, objective behind building econometric models, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions.	15
2	Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.	15
3	Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.	15
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.	15
	Practical Work: 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 9. Estimation of problems of General linear model under Autocorrelation 10. Problems related to consequences Heteroscedasticity 11. Diagnostics of Heteroscedasticity 12. Estimation of problems of General linear model under Heteroscedastic distance terms	30

	13. Problems related to General linear model under (Aitken Estimation) 14. Problems on Autoregressive and Lag models.	
	TOTAL	90

Reading List:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.

SEMESTER – VI

STAT DSE604 (Demography and Vital Statistics)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Comprehend the basic concepts and definitions in demography.

CO2: Understand the core social demographic variables, and how these variables influence population growth, composition and structure.

CO3: Develop knowledge of the basic measures of mortality & fertility in order to understand the population dynamics as well as for the development planning process.

CO4: Discuss global demographic regimes and impact on public health.

CO5: Understand the techniques for measuring longevity - Life tables which deals with computations of future population size and it can also be used in actuarial science.

<u>STAT DSE604: Demography and Vital Statistics (Practical)</u>		
PWC (Theory: 4 Credits + Practical: 2 Credits)		
Units	Topics to be covered	No. of Hours
1	Demography: Definition and scope, errors in demographic data, use of balancing equations and Chandrasekharan-Deming method to check completeness of registration data. Population composition, Dependency ratio.	15
2	Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.	15
3	Stationary and Stable population, Central Mortality Rates. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.	15
4	Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method and King's Method. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).	15

	Practical Work: 1. To calculate CDR and Age Specific death rate for a given set of data 2. To find Standardized death rate by (i) Direct method (ii) Indirect method 3. To construct a complete life table 4. To fill in the missing entries in a life table 5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) King's Method 6. To calculate CBR, GFR, SFR, TFR for a given set of data 7. Calculate GRR and NRR for a given set of data and compare them.	30
	TOTAL	90

Reading List:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons.
4. Phathak, K.B and Ram, F.: Techniques of Demographic Analysis, Himalaya Publishing House.
5. Ramkumar, R. (2018): Technical Demography, 2nd Edition, New Age International.

Skill Enhancement Course (SEC) (2 Credits)

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

Semester III

IRS SEC301: Inter-Religious Studies (Value Based)

After the completion of the course, the student will be able to:-

CO1: Develop Inter-religious harmony & better understanding of other religions.

CO2: Interpret the different religions of the world.

CO3: Identify the common elements that bind different religions together.

CO4: Acquaint with the salient features of different religions.

<u>IRS SEC301: Inter-Religious Studies (Value Based) (2 Credits)</u>		
PWC		
Unit	Topics to be covered	No. of Hours
1	Nature and Need of Inter-Religious study, Scope of Comparative Religion.	05
2	Salient Features of Hinduism, Jainism and Buddhism, Salient Features of Christianity, Islam and Sikhism.	10
3	Similarities and Differences among Religions, Conflicting Truth claims of different religions and inter-religious Harmony.	10
4	Religious Tolerance, Secularism.	05
	TOTAL	30

Reading List:

1. Chaudhary, C. Neeraj (1979). "Hinduism", B. I. Publication, New Delhi.
2. Devraj, N. K. (1917): "Hinduism and Christianity" Asian Publishing House.
3. Gordh, George – "Christian Faith and its Cultural Exoperssion", Printed in USA.
4. Hick, John – "Philosophy of Religion", Prentice Hall of India.
5. Hopfe, M. Lewis (1983): "Religion of the World", Macmillan Publishing Co. Inc, New York.
6. Masih, Y. (1990): "Comparative Study of Religion", Motilal Banarasidass.

7. Sethi, S. Arijit, Pummer, Reinhard (1979): “Comparative Religion”, Vikas Publishing House Pvt. Ltd, Delhi.
8. Singh, B.N. (1994): “Vishwa Dharma Darshan ki Samasyain” Ratna Printing Works.
9. Tiwari, Nath Kedar (1983): “Comparative Religion”, Motilal Banarasidass.
10. Ward, CHS (1998): “Early Buddhism”, Caxton Publication, Delhi.

Semester IV

STAT SEC 402 Minitab (Statistical data analysis using statistical software packages)

Course Outcomes:

After Completion of the course, student will be able to:-

CO1: Learn how to analyse the data, identify the problems and choose the relevant techniques to apply.

CO2: Develop the skills to know when and where to use the various types of control charts available in Minitab for own processes.

CO3: Gets an idea how Minitab makes it simpler than ever to get deep insights from the data.

STAT SEC402: Statistical Data Analysis using Statistical Software Packages		
PWC (Theory: 2 Credits)		
This course will review and expand upon core topics in statistics and probability, particularly by initiating the beneficiaries of the course to at least one of the software packages, viz., SPSS, Minitab for statistical computing.		
Units	Topics to be covered	No. of Hours
1	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.	7
2	Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.	8
3	Random number generation and sampling procedures. Fitting of polynomials and exponential curves. Application Problems based on fitting of suitable distribution, Normal probability plot.	7
4	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.	8
TOTAL		30

Reading List:

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.