Choice Based Credit System (CBCS)

UNIVERSITY OF DELHI

DEPARTMENT OF STATISTICS

BACHELOR OF SCIENCE (Programme)
(B.Sc. (Programme) Mathematical Sciences)

(Effective from Academic Year 2018-19)

PROPOSED SYLLABUS

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2018 and Executive Council on YYYY, 2018

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I. About the Department

The Department of Mathematical Statistics was established in August 1973, though the teaching of M.A. in Mathematical Statistics had been introduced as early as in July 1957 at the initiative of Professor Ram Behari as part of a development programme adopted by the Department of Mathematics. Professor H.C. Gupta was the first head of the Department and he can be credited with the setting up of a good school in Stochastic Processes. . In 1971, the scope of post-graduate course in Mathematical Statistics was extended leading to M.Sc. degree in Statistics.

In 1987, the Department of Mathematical Statistics was re-named as the Department of Statistics. The Department is running the post-graduate (M.A./M.Sc.), M.Phil. and Ph.D. programmes in Statistics.

The Department imparts rigorous training and exposure to the students in computer education by way of introducing the latest state-of-the-art in the programming language and computer software to enable to the students to perform statistical data analysis. With a view to preparing research background of the students, the M.Phil. Course in Mathematical Statistics was introduced in 1977 and the same has been continually updated covering most of the areas of Theoretical and Applied Statistics at the specialization level.

The Department has laboratories equipped with the basic and modern computing facilities. There is a good collection of books in department with latest titles in various areas of statistics. Two computer laboratories with latest computing systems and related equipment have been setup in the Department for the use of students, research scholars and teachers. Regarding the job opportunities, the Department has a placement cell operating since academic year 2005-06. The department also has Research Activity Cell, UDAAN-The Socio-Cultural cell and Heritage Club operating since the academic year 2016-17. We can take pride in the fact that students get suitable placement in Research Institutes or Industries or Government Departments. Significant number of students are selected in the prestigious Indian Statistical Service (ISS) each year.

II. Introduction to CBCS (Choice Based Credit System)

Scope:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on students' performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) 'Course' means a segment of a subject that is part of an Academic Programme.

(iii) 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission.

(iv) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi) 'Discipline Specific Elective' (DSE) course is the domain specific elective course offered by the main discipline/subject of study. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature also, but these are needed to be offered by main discipline/subject of study.

(vii) 'Dissertation/Project' is an elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member. Project work/Dissertation is considered as a special course involving application of

knowledge in solving / analysing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

(viii) 'Generic Elective' (GE) course is an elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure to other disciplines. 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.

(ix) 'Ability Enhancement Courses' (AEC) also referred as Competency Improvement Courses/Skill Development Courses/Foundation Course. The Ability Enhancement Courses (AEC) may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC).

(x) 'AECC' are the courses based upon the content that leads to Knowledge enhancement. The two AECC are: Environmental Science, English/MIL Communication.

(xi) 'AEEC' are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction. These courses are also referred to as Skill Enhancement Courses (SEC).

(xii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(xiii) 'CGPA' is cumulative grade points calculated for all courses completed by the students at any point of time.

(xiv) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(xv) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(xvi) 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

CBCS Course Structure for B.Sc. (Programme)

Semester	Core Course (12)	Ability Enhancement Compulsory Course(AECC) (2)	Skill Enhancement Course(SEC) (2)	Discipline Specific Elective (DSE)(6)	Generic Elective GE (2)
1	DSC -1 (Core 1)	**AECC1**			
	DSC -2 A				
	DSC -3 A				
2	DSC -1 (Core 2)	**AECC2**			
	DSC -2 B				
	DSC -3 B				
3	DSC -1 (Core 3)		**SEC1 (SE – 1)**		
	DSC -2 C				
	DSC -3 C				
4	DSC -1 (Core 4)		**SEC2 (SE – 2)**		
	DSC -2 D				
	DSC -3 D				
5			**SEC3 (SE – 3)**	**DSE 1 [DSE 1 (i) / (ii)]**	
				DSE 2A	
				DSE 3A	
6			**SEC4 (SE – 4)**	**DSE 1 [DSE 2 (i) / (ii)]**	
				DSE 2B	
				DSE 3B	

LIST OF THE COURSES

Core Courses (DSC)

Core1: Descriptive Statistics and Probability Theory

Core2: Statistical Methods

Core3: Statistical Inference

Core4: Sample Surveys and Design of Experiments

Skill Enhancement Courses (SEC)

SE 1: Data Analysis using Software

SE 2: Statistical Computing using C

SE 3: Statistical Simulation

SE 4: Statistical Techniques for Research Methods

Discipline Specific Electives (DSE)

DSE1 (choose one)

DSE 1 - (i) Vital Statistics

DSE 1 - (ii) Quality Control

DSE2 (choose one)

DSE 2 - (i) Index Number and Time Series Analysis

DSE 2 - (ii) Econometric Theory

Note:

1. There will be one batch of 15 students for practical classes.
2. Each practical will carry 50 marks including 25 marks for continuous evaluation and 5 marks for the oral test.
3. Colleges are advised and encouraged to conduct at least 50% of the practicals using spreadsheet (MS Excel) or any statistical package (SPSS/R/MATLAB).
4. At least four questions have to be compulsorily attempted in the final practical examination.
5. Hardcopy of practical file has to be maintained by the students for each practical paper.

III. B.Sc. (Programme) Details:

Programme Objectives (POs)

1. To imbibe strong foundation of statistics in students.
2. To familiarize students with basic to high-level statistical concepts.
3. To update students with mathematical tools that aid in statistical theory.
4. To teach/strengthen students' knowledge of spreadsheets, programming languages and statistical packages.
5. To promote application-oriented pedagogy by exposing students to real word data.
6. To make students do projects which prepares them for jobs ahead.

Programme Outcomes (PCOs)

This course exposes the students to the beautiful world of Statistics and how it affects each and every aspect of our daily life. The course is designed to equip students with all the major concepts of Statistics along with the tools required to implement them. Introduction to computer softwares help them in analysis of data by making optimum usage of time and resources. These sofwares give them the necessary support and an edge when progressing to their professional careers. Exposure to plethora of real life data helps in honing their analysing skills. Having practical component with every paper invokes their exploratory side and fine-tunes the interpretation abilities. Such a pedagogy goes a long way in giving them the required impetus and confidence for consultancy startups/jobs in near future. The structure of the course also motivates/helps the students to pursue careers in related disciplines, especially the actuarial sciences.

Programme Structure:

The BSc. (Programme) is a three-year course divided into six-semesters. A student is required to complete 132 credits for the completion of course and the award of degree.

		Semester	***Semester***
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV
Part – III	Third Year	Semester IV	Semester VI

Semester wise Details of B.Sc. (Programme) Course & Credit Scheme

Course	***Credits**	
	Theory+Practical	Theory +Tutorials
I. Core Course (12 Papers) 04 Courses from each of the 03 Disciplines of choice	12×4=48	12×5=60
Core Course Practical/Tutorial* **(12 Practical/Tutorials*)** 04 Courses from each of the 03 Disciplines of choice	12×2=24	12×1=12
II. Elective Course **(6 Papers)**	6×4=24	6×5=30
Two papers from each discipline of choice including paper of interdisciplinary nature.		
Elective Course Practical/Tutorials* **(6 Practical/Tutorials*)**	6×2=12	6×1=6
Two Papers from each discipline of choice including paper of interdisciplinary nature		
Optional Dissertation or project work in place of one Discipline elective paper (6 credits) In 6th Semester		
III. Ability Enhancement Courses		
1. **Ability Enhancement Compulsory** (2 Papers of 4 credits each)	2×4=8	2×4=8

Environmental Science

English/MIL Communication

2. **Skill Enhancement Course**	4×4=16	4×4=16
(Skill Based)(4 Papers of 4 credits each)		
	Total credit=132	**Total credit=132**

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 tutorials and vice-versa.**

Teaching:

The faculty of the Department is primarily responsible for organizing lecture work for B.Sc. (Programme). The instructions related to tutorials are provided by the respective registering units under the overall guidance of the Department. Faculty from some other Departments and constituent colleges are also associated with lecture and tutorial work in the Department.

There shall be 90 instructional days excluding examination in a semester.

(Add details about Projects/Dissertation and role of supervisor)

Teaching Pedagogy:

Teaching pedagogy involving class room interactions, discussion, presentation etc. to be detailed out. The description should not be more than 300 words and could be both in general for all the courses and even for some particular papers requiring specific pedagogy like project work, group activities, or live projects.

This section (for each paper) could include the class-wise/week-wise flow of the course.

Eligibility for Admissions:

Mention the basis of admission to the B.Sc. (Programme), preferable point wise- Mode of Admission -Entrance and Interview or only Entrance, Eligibility Criteria, Courses coverage for Entrance Test.

Assessment Tasks:

Comprising MCQs, Project work and presentations, design and production of course related objects, written assignments, open or closed book exams specifically designed to assess the Learning Outcomes. (Evidence of achieving the Outcomes).

Assessment of Students' Performance and Scheme of Examinations:

1. English shall be the medium of instruction and examination.
2. Assessment of students performance shall consist of:
   (Point wise details of internal assessment and end semester examination, their weightage and scheme to be given)
   (Assessment will be based on Learning Outcomes for the course)

Pass Percentage & Promotion Criteria:

(Provide point wise details about Pass percentage & Promotion Criteria)

Semester to Semester Progression:

(Provide department policy about semester to semester progression, policy for re-appearance, policy in case of failing in one or more papers)

Conversion of Marks into Grades:

(Specify the formula for conversion of marks into grades)

Grade Points:

Grade point table as per University Examination rule.

CGPA Calculation:

As per University Examination rule.

SGPA Calculation:

As per University Examination rule.

Grand SGPA Calculation

As per University Examination rule.

Conversion of Grand CGPA into Marks

As notified by competent authority the formula for conversion of Grand CGPA into marks is:
Final %age of marks = CGPA based on all four semesters × 9.5

Division of Degree into Classes:

Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.

Attendance Requirement:

(Specify components for marking attendance of students)

Span Period:

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of **five** years from the date of admission to the Part-I/Semester-I of the B.Sc. (Programme).

Guidelines for the Award of Internal Assessment Marks B.Sc. (Programme) (Semester Wise)

(Mention the components of Internal Assessment and the scheme for awarding marks for students' attendance)

IV: Course Wise Content Details for B.Sc. (Programme)

B.Sc. (Programme) Mathematical Sciences

Semester-I

Core 1: Descriptive Statistics and Probability

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- Introduction to Statistics.
- Graphical representation of data.
- Understanding the concept of Probability.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of statistics.
- Handling various types of data and their graphical representation.
- Measures of location and dispersion.
- Bivariate data. Significance of various coefficients of correlation.
- Fitting of linear and nonlinear curve.
- Probability theory and its applications.

Unit I: Concepts of a statistical population and sample from a population, quantitative and qualitative data, nominal, ordinal and time-series data, discrete and continuous data. Presentation of data by tables and by diagrams, frequency distributions for discrete and continuous data, graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods).

Unit II: Measures of location (or central tendency).Measures of Dispersion, range, quartile deviation, mean deviation, standard deviation, coefficient of variation. Moments, measures of skewness and kurtosis, cumulants.

Unit III: Bivariate data: Scatter diagram, principle of least-square and fitting of polynomials and exponential curves. Correlation and regression. Karl Pearson’s coefficient of correlation,

Lines of regression, Spearman's rank correlation coefficient, multiple and partial correlations (for 3 variates only).

U**nit IV:** Probability: Introduction, Random experiment, sample point and sample space, event, algebra of events, Definition of Probability - classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorems on probability, conditional probability, independent events. Bayes theorem and its applications.

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics, Vol. I, 8th Ed., World Press, Kolkatta.
2. Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
3. Hogg, R. V., McKean, J., and Craig, A. T. (2005). Introduction to mathematical statistics. Pearson Education.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication.
5. Freund, J.E. (2009). Mathematical Statistics with Applications, 7th Ed., Pearson Education.

Practical/Lab Work

List of Practicals:

1. Problems based on graphical representation of data. Histograms (equal class intervals and unequal class intervals), frequency polygon, ogive curve.
2. Problems based on measures of central tendency using raw data, grouped data for change of origin and scale.
3. Problems based on measures of dispersion using raw data, grouped data for change of origin and Scale.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on Moments using raw data, grouped data for change of origin and scale
6. Relationships between moments about origin and central moments.
7. Problems based on skewness and kurtosis.
8. Karl Pearson’s correlation coefficient (with/without) change of scale and origin.
9. Lines of regression, angle between lines and estimation of parameters.
10. Lines of regression and regression coefficients.

11. Spearman rank correlation with/without ties.
12. Fitting of polynomials and exponential curves.

Week-wise teaching plan:

Week 1-3	Introduction to Statistics. Various types of data and presentation of data by tables, Graphs and Frequency Distributions. Practical work.
Week 3-5	Measures of Location and Dispersion.
Week 5	Moments. Interrelationship between central moments and moments about any point. Practical work.
Week 6-7	Skewness and Kurtosis. Practical work.
Week 7-9	Bivariate Data, Correlation coefficient. Practical work.
Week 9-10	Principle of least squares, Lines of regression. Practical work.
Week 10-12	Probability Theory, Definition of Probability, Theorems on probability.
Week 12-14	Conditional Probability, Independent Events.
Week 14	Bayes' Theorem and its applications.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Importance and scope of Statistics.	Class room lectures and discussions.	Participation in class discussion.
I	Types of data and their graphical representation.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
II	Measures of central tendency and dispersion. Merits and their demerits.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
II	Concept of moments. Measures of skewness and kurtosis.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
III	Scatter diagram. Principle of least squares and fitting of polynomial and exponential curves.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
III	Karl Pearson's correlation coefficient and Spearman's correlation coefficient.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.
III	Lines of regression and their properties.	(i) Class room lectures and discussions. (ii) Practical work	Participation in class discussion.

			Class test/assignment on first two units/unit.
IV	Introduction to probability. Axioms of probability and various theorems on probability.	Class room lectures and discussions.	Participation in class discussion.
IV	Conditional probability and independent events.	Class room lectures and discussions.	Participation in class discussion.
IV	Bayes' theorem and its applications.	Class room lectures and discussions.	Participation in class discussion.
			Class test/assignment on last unit.

B.Sc. (Programme) Mathematical Sciences

Semester-II

Core 2: Statistical Methods

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- To familiar with basic concepts of Mathematical Statistics.
- To understand the nature of data with the help of various statistical tools.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of Mathematical Statistics.
- Basic concept of random variable and its types.
- Introduction to pmf, pdf and cdf.
- Properties of random variables like expectation, moment generating function, cumulative generating function etc.
- Bivariate probability distribution.
- Marginal and conditional probability distributions.
- Independence of variates.
- Transformation in univariate and bivariate distributions.
- Various discrete and continuous probability distributions like Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Normal, Uniform, Exponential, Beta and Gamma distributions.
- Markov and Chebychev's inequality.
- Statement and applications of WLLN and SLLN.
- Central limit theorem (CLT) for i.i.d. variates, and its applications.

Unit I: Random variables: Discrete and continuous random variables, pmf, pdf and cdf, illustrations of random variables and it properties, expectation of random variable and its properties. Moments and cumulants, moment generating function, cumulants generating function and characteristic function.

Unit II: Bivariate probability distributions, marginal and conditional distributions, independence of variates (only general idea to be given). Transformation in univariate and bivariate distributions.

Unit III: Point (or degenerate) Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Normal, Uniform, Exponential, Beta and Gamma distributions.

Unit IV: Markov inequality, Chebychev's inequality, WLLN and SLLN: Statement and applications, Central Limit Theorem (CLT) for i.i.d. variates, and its applications.

Suggested Readings:

1. Goon, M., Gupta, M.K. and Dasgupta, B. (2003). An outline of Statistical Theory, Vol. I, 4th Ed., World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
3. Hogg, R. V., McKean, J., and Craig, A. T. (2005). Introduction to mathematical statistics. Pearson Education.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007). Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication.
5. Rohtagi, V.K. and Saleh, A.K. Md. E. (2009). An Introduction to Probability and Statistics, 2nd Ed., John Wiley and Sons.
6. Ross, S .A. (2007). Introduction to Probability Models, 9th Ed., Academic Press.

Practical/Lab Work

List of Practicals:

1. Fitting of binomial distributions for n and p = q = ½ and for n and p given.
2. Fitting of binomial distributions computing mean and variance.
3. Fitting of Poisson distributions for give n and λ and after estimating mean.
4. Fitting of negative binomial.
5. Fitting of suitable distribution.
6. Application problems based on Binomial distribution.
7. Application problems based on Poisson distribution.
8. Application problems based on negative Binomial distribution.
9. Problems based on the Area property of Normal distribution.
10. Application problems based on Normal distribution.
11. Fitting of normal distribution when parameters are given/not given.

Week-wise Teaching Plan:

Week 1	Random variables: Discrete and continuous random variables, pmf, pdf and cdf with numerical problems.
Week 2	Illustrations of random variables and it properties, expectation of random variable and its properties with numerical problems.
Week 3	Expectation of random variable and its properties with examples.
Week 4-5	Moments and cumulants, moment generating function with examples. Cumulant generating function and characteristic function with properties.
Week 6	Bivariate probability distributions, marginal and conditional distributions with numerical problems.
Week 7	Independence of variates, transformation in univariate and bivariate distributions.
Week 8-9	Point (or degenerate) Binomial distribution and Poisson distribution with its properties along with applications. Geometric distribution and Negative Binomial distribution, its properties and applications.
Week 10	Hypergeometric distribution and Normal distribution, its properties and applications.
Week 11-12	Uniform and Exponential distribution, its properties and applications. Beta and Gamma distributions, its properties and applications.
Week 13-14	Markov inequality and Chebychev's inequality, its statement and applications. WLLN and SLLN: Statement and applications.
Week 15	Central Limit Theorem (CLT) for i.i.d. variates and its applications.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The fundamental concepts of mathematical statistics.	Class room lectures and discussions.	Participation in class discussion.
I	Basic concept of random variable and its types.	Class room lectures and discussions.	Participation in class discussion.
I	Introduction to pmf, pdf and cdf.	(i) Class room lectures and discussions.	(i) Participation in class discussion.
I	Properties of random variables	(ii) Practical work	(ii) Introduction of

	like expectation, moment generating function, cumulative generating function etc.	based on the properties of random variable like expectation, mgf and cgf.	various properties of random variable like expectation, mgf and cgf, its applications in real life scenario.
II	Bivariate probability distribution. Marginal and conditional probability distributions.		
A*	Random variables and its properties, Marginal and conditional probability distributions.	Class Test/Assignment work.	Extent of clarity in theoretical concepts
II	Independence of variates. Transformation in univariate and bivariate distributions.	(i)Class room lectures and discussions. (ii) Practical work based on the transformation in univariate and bivariate distribution. (iii) Practical work based on these distribution.	(i) Participation in class discussion. (ii) Identification of different methods of transformation from univariate to bivariate with numerical examples. (iii) Understanding of different situation in which various distributions are applied.
III	Various discrete and continuous probability distributions like Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Normal, Uniform, Exponential, Beta and Gamma distributions.		
IV	Markov and Chebychev's inequality. Statement and applications of WLLN and SLLN. Central limit theorem(CLT) for i.i.d. variates, and its applications		
B*	Discrete & continuous probability distribution	Class Test/ Assignment work	Extent of clarity in theoretical concepts.
C*	Chebychev's inequality, WLLN and SLLN, Central limit theorem	(i) Project Work and its presentation. (ii) Real life examples of CLT.	(i) Understanding of situations in which various inequalities are applicable.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. (Programme) Mathematical Sciences

Semester-III

Core 3: Statistical Inference

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- Concept of small sample and large sample tests.
- Concept of Testing of hypothesis and estimation theory.
- To analyze and interpret the data vis-à-vis statistical inference.

Course Learning Outcomes:

After completing this course, students will possess skills concerning:

- Parameter, statistic, standard error, sampling distribution of a statistic, hypothesis testing, etc.
- Sampling distributions of chi-square, t and F and their applications.
- Characteristics of a good estimator, different methods of estimation.
- Demonstrate use of these techniques in data analysis.

Unit I: Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors, power of a test and critical region. Sampling distribution of a statistic, sampling distribution of sample mean, standard error of sample mean.

Unit II: Large sample tests for single mean, difference of means**,** standard deviation and difference of standard deviations. Sampling distributions of chi-square, t and F: definitions, properties and relationships between them. Tests of Significance based on Chi-square (goodness of fit and independence of attributes), t distribution and F distribution using classical and p-value approach.

Unit III: Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased

estimators. Cramer-Rao inequality: statement and application, Methods of estimation: maximum likelihood, least squares and minimum variance, statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem. Properties of maximum likelihood estimators (illustration), Interval Estimation: confidence intervals for the parameters of Normal distribution, confidence intervals for difference of mean and for ratio of variances.

Unit IV: Neyman-Pearson lemma and MP test: Statements and applications.

Suggested Readings:

1. Casella, G. and Berger, R. L. (2002). Statistical Inference, 2nd Ed, Thomson Duxbury.
2. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley and Sons.
3. Goon A.M., Gupta M.K. and Dasgupta B. (2003). An Outline of Statistical Theory, Vol. II, 4th Ed., World Press, Kolkata.
4. Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons.
5. Hogg, R.V., McKean, J., and Craig, A.T. (2005). Introduction to mathematical statistics, Pearson Education.
6. Rohtagi, V.K. and Saleh, A.K.Md.E. (2009). An Introduction to Probability and Statistics, 2nd Ed, John Wiley and Sons.

Practical/Lab Work

List of Practicals:

1. Large Sample Tests (Based on normal distribution).
2. Testing of goodness of fit.
3. Testing of independence of attributes based on 2 x 2 contingency table.
4. Testing of equality of two populations variances.
5. Applying the paired t-test for difference of means.
6. Maximum Likelihood Estimation.
7. Confidence interval for Binomial proportion.
8. Confidence interval for the difference of proportions.
9. Confidence interval for difference of population means.
10. Confidence interval for ratio of variances.
11. Type I and Type II errors.
12. Most powerful critical region (NP Lemma).

Week-wise Teaching Plan:

Week 1-2	Definitions of random sample, parameter and statistic, null and alternative hypotheses, simple and composite hypotheses, level of significance and probabilities of Type I and Type II errors, power of a test and critical region. Practical Work.
Week 3	Sampling distribution of a statistic, sampling distribution of sample mean, standard error of sample mean. Practical Work.
Week 4-5	Large sample tests for single mean, difference of means, standard deviation and difference of standard deviations. Practical Work.
Week 6-7	Sampling distributions of chi-square, t and F: Definitions, Properties and Relationships between them.
Week 8-9	Tests of Significance based on Chi-square (goodness of fit and independence of attributes), t distribution and F distribution using classical and p-value approach. Practical Work.
Week 10	Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency.
Week 11	Minimum variance unbiased estimators. Cramer- Rao inequality: statement and application.
Week 12-13	Methods of estimation: maximum likelihood, least squares and minimum variance, statement of Rao-Blackwell theorem and Lehmann-Scheffe theorem. Properties of maximum likelihood estimators (illustration). Practical Work.
Week 13-14	Interval Estimation: confidence intervals for the parameters of normal distribution, confidence intervals for difference of mean and for ratio of variances. Practical Work.
Week 15	Neyman-Pearson lemma and MP test: statements and applications; Practical Work.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The concepts and definitions of random sampling and basic	Class room lectures and discussions.	Participation in class discussion.

	sampling theory.		
I	Introduction to testing of hypothesis and types of errors.	Class room lectures and discussions.	Participation in class discussion.
II	Large sample theory.	(i) Class room lectures and discussions. (ii) Practical work based on the large sample theory.	(i) Participation in class discussion. (ii) Identification of random sample, test, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion.
II	Sampling distributions.		
II	Tests based on sampling distributions.		
A*	Understanding of basic concept of random sampling and testing of hypothesis.	Class Test/ Assignment work	Extent of clarity in theoretical concepts
III	Introduction to Estimation Theory	(i) Class room lectures and discussions. (ii) Practical work based on the theory of estimation.	(i) Participation in class discussion. (ii) Identification of random sample, method of estimation, appropriate analysis, interpretation of results and conclusion.
III	Characteristics of a good estimator, methods of estimation and interval estimation.		
IV	Neyman-Pearson Theory		
B*	Understanding of estimation theory, Point and interval estimations, Neyman-Pearson theory.	Class Test/ Assignment work	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. (Programme) Mathematical Sciences

Semester-IV

Core 4: Sample Surveys and Design of Experiments

Credits: 6 **Marks: 150**

Course Objectives:

- To learn about sample surveys, its need and objectives.
- To learn to draw appropriate sample and interpret the result.
- To learn to design and conduct experiments.
- To analyze and interpret the data.
- To know about official statistical system in India and functions of different agencies.

Course Outcomes:

After completing this course, students have a clear understanding of:

- The basic concept of sample survey and its need.
- Simple random sampling.
- Stratified random sampling.
- Systematic sampling.
- One-way and two-way analysis of variance.
- Basic concepts of design of experiments.
- Completely randomized design.
- Randomized design.
- Latin square design.
- Missing plot techniques.
- Factorial experiments.
- Present official statistical system in India.
- Functions of C.S.O. and N.S.S.O.

Unit I: Indian Official Statistics: Present Official Statistical System in India relating to census of population, agriculture, industrial production, and prices; methods of collection of official statistics, major publications, their reliability and limitations. Agencies responsible for the data collection- C.S.O., N.S.S.O., Office of Registrar General: historical development, main functions and important publications.

Sample Surveys: Basic concepts of sample survey, concept of sampling, need for sampling, complete enumeration v/s sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors.

Simple random sampling (SRSWR and SRSWOR): Definition and procedures of selecting a sample, properties of simple random sample, estimation of mean and sampling variance of sample mean.

Unit II: Stratified random sampling: introduction, estimation of population mean and its variance, choice of sample sizes in different strata, comparison of stratified sampling under dproportional and Neyman allocation with SRSWOR in terms of precision. Systematic sampling: introduction to linear systematic sampling, estimation of sample mean and its variance (N=nk), comparison of systematic sampling with SRSWOR in terms of mean squares.

Unit III: Analysis of variance: one-way and two-way classified data with one observation per cell only. Design of experiments: Principles of Design of experiments, uniformity trails, completely randomized, Randomized block and Latin square designs.

Unit IV: Missing plot technique: Analysis with a single missing observation: Missing plot technique for RBD and LSD. Factorial experiments: 2^2 and 2^3 Factorial experiments: construction and analysis.

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). Fundamentals of Statistics, Vol. II, 8th Ed., World Press, Kolkata.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II, 3rd Ed., World Press, Kolkata.
3. Gupta, S.C. and Kapoor, V.K. (2008). Fundamentals of Applied Statistics, 4th Ed., Sultan Chand and Sons.
4. Montgomery, D.C. (2001). Designs and Analysis of Experiments, John Wiley and Sons, New York.
5. Mukhopadhyay, P. (1998). Theory and Methods of Surveys Sampling, Prentice Hall of India.
6. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
7. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
8. http://mospi.nic.in/

Practical/Lab Work

List of Practicals:

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size.
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Analysis of one way/two way ANOVA.
8. Analysis of CRD, RBD.
9. Analysis of LSD.
10. Analysis of RBD with one missing observation.
11. Analysis of LSD with one missing observation.
12. Analysis of 2^2 and2^3 factorial in CRD and RBD.

Week-wise teaching plan:

Week 1	Indian Official Statistics: Present Official Statistical System in India relating to census of population, agriculture, industrial production, and prices; methods of collection of official statistics, major publications, their reliability and limitations. Agencies responsible for the data collection- C.S.O., N.S.S.O., Office of Registrar General: historical development, main functions and important publications. Presentations.
Week 2-3	Sample Surveys: Basic concepts of sample survey, concept of sampling, need for sampling, complete enumeration v/s. sampling, principles of sampling theory, principal steps in a sample surveys, planning and organization of a sample survey, sampling and non-sampling errors.
Week 3-4	Simple random sampling (SRSWR and SRSWOR): Definition and procedures of selecting a sample, properties of simple random sample, estimation of mean and sampling variance of sample mean. Practical Work.

Week 5-6	Stratified random sampling: Introduction, estimation of population mean and its variance, choice of sample sizes in different strata, comparison of stratified sampling under proportional and Neyman allocation with SRSWOR in terms of precision. Practical Work.
Week 6-7	Systematic sampling: Introduction to linear systematic sampling, estimation of sample mean and its variance (N=nk), comparison of systematic sampling with SRSWOR in terms of mean squares. Practical Work.
Week 8-9	Analysis of Variance: One-way and two-way classified data with one observation per cell only. Practical Work.
Week 9-10	Design of Experiments: Principles of Design of experiments, uniformity trails
Week 11-12	Completely Randomised Design (CRD), Randomised Block Design (RBD) and Latin Square Design (LSD): Introduction, Structure, Model and Parameters, ANOVA, Advantages and Disadvantages, Uses. Practical Work.
Week 13	Relative efficiencies of RBD compared to CRD, LSD compared to CRD, LSD compared to RBD taking rows and columns as blocks. Practical Work.
Week 14	Missing plot technique. Analysis under a single missing observation: Missing plot technique (for RBD and LSD), Variance of the difference between two estimated treatment effects out of which one has 1 missing observation for both RBD and LSD. Practical Work.
Week 15	2^2 and 2^3 Factorial experiments: Introduction, Terminology, Main effects and interactions, Notation, Standard order for treatment combinations, ANOVA, Yate's Algorithm. Practical Work.

Facilitating the achievement of Course Learning Outcomes

Serial No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Indian Official Statistics	Class room lectures and discussion	(i) Participation in class discussion (ii) Presentations
I	Basic concepts of Sample Surveys	Class room lectures and discussion	Participation in class discussion
II	Simple random sampling,	(i) Class room	(i) Participation in class

	Stratified random sampling, systematic sampling	lectures and discussion\ (ii) Practical work based on these sampling	discussion (ii) Distinguishing between different types of sampling and their applications (iii) Class test/ assignment
III	Analysis of Variance: one-way and two-way classified data with one observation per cell	(i) Class room lectures and discussion (ii) Practical work based on these ANOVA	(i) Participation in class discussion (ii) Understanding the layout, formulation of hypothesis, model, appropriate analysis, interpretation of result and conclusions
III	Design of experiments: CRD, RBD and LSD	(i) Class room lectures and discussion (ii) Practical work based on these design.	(i) Participation in class discussion (ii) Understanding the layout, formulation of hypothesis, model, appropriate analysis, interpretation of result and conclusions. (iii) Class test/assignment
IV	Factorial designs with two or three levels	(i) Class room lectures and discussion (ii) Practical work based on these design.	(i) Participation in class discussion (ii) Understanding the layout, identification of design, appropriate analysis, interpretation of result and conclusions (iii) Class test/assignment (iv) Project work and presentations

B.Sc. (Programme) Mathematical Sciences

Semester-III

SE 1: Data Analysis using Software

Credits: 4 **Marks: 100**

Course Objectives:

The learning objectives include:

- To understand SPSS/R and its roles in problem solving.
- To understand data handling and its analysis
- Learning the basic statistical software will help students to easily switch over to any other statistical software in future.

Course Learning Outcomes:

- Understand the basic workings of SPSS/R, and perform basic statistical analyses.
- To perform descriptive statistics and graphics, and basic inferential statistics for comparisons and correlations using SPSS/R.
- Importing data, Code editing in SPSS/R.

This course will review topics in probability and statistics studied in core for data analysis. Introduction to SPSS/R for statistical computing, analysis and graphical interpretation would be done using software skills. The following problems can be done on any one of the statistical software to enhance data analysis skills using software.

Unit I: Graphical representation of data by histograms, frequency polygon, Pie chart, ogives, boxplot and stem-leaf. Measures of central tendency, dispersion.

Unit II: Correlation and regression.

Unit III: Fitting of polynomials, exponential curves. Generation of random samples from probability distributions and plotting them.

Unit IV: Testing of hypothesis, sampling procedures.

Suggested Readings:

1. Cunningham, B.J. (2012). Using SPSS: An Interactive Hands-on approach.
2. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley Publications.

Practical/Lab Work

List of Practicals:

1. Draw histogram for equal/unequal width class interval, Stem and Leaf plot, Box plot frequency polygon, pie chart, bar graphs, line charts, ogive.
2. Construct frequency table using recode (having equal and unequal interval) and visual binning.
3. Compute descriptive statistics for raw data and grouped data and interpret by computing coefficient of variation, skewness and kurtosis.
4. Use of compute and compute with if feature.
5. Calculate correlation coefficient (Karl Pearson), Spearman's rank correlation coefficient, and Partial correlation coefficient and fitting of two lines of regression and their plot.
6. Generation of random sample from Binomial, Poisson, Uniform, Exponential and Normal distributions. Stem and Leaf plots and Box Plots for these random Samples.
7. Draw simple random sample with/without replacement and compute various measures by select cases.
8. Fit linear, quadratic and exponential curve and find which one is best suited from the graph.
9. Construct bivariate distribution using recode.
10. t-test for single mean, difference of means and Paired t-test, F-Test, Chi Square test for independence of attributes for raw data (using crosstab feature) and Chi Square test for independence of attributes (given contingency table), chi square test for goodness of fit and comparison of several means (ANOVA).
11. How to edit syntax, save it and retrieve it for subsequent analyses with the help of relevant example and Data import from other packages and export to other packages.

Week-wise Teaching Plan:

Week 1	Introduction to SPSS: how to enter variable names and data. Generate a table of statistics and graph summarizing those statistics. Navigate the Variable View and Data View screens. Investigations of main menu and data editor tool bar. Save and open data and output files. To distinguish between variables measured at the nominal, ordinal and scale levels of measurements. To enter variables and their attributes.
	Introduction to R, Installation of packages and modules, loading of data,

	playing with arithmetic expressions. Introduction to data types.
Week 2	Use of count, compute, compute with if and select if rank feature.
	User defined functions, Introduction to flow control: if(), for() and while() loop. Practical Work.
Week 2-3	Concept of recode and visual binning in SPSS, generation of frequency tables, to calculate measures of central tendency and measure of dispersion using SPSS/R. Practical Work.
Week 4	To create basic graphs using Legacy Dialogs and Chart Builder methods, to edit basic graphs. Practical Work.
	Graphical representation and interpretation viz. bar-plot, pie-chart, histograms (equal class intervals and unequal class intervals), frequency polygon, ogives with graphical summaries of data using R. Practical Work.
Week 5	Computation and interpretation of correlation coefficient (Pearson's and Spearman's). Test of significance for Pearson's correlation coefficient and Partial correlation coefficients using SPSS/R. Practical Work.
Week 6	Fitting and plotting of regression lines using SPSS/R. Practical Work
Week 7	Fitting of polynomial and exponential curves using built in functions. Fitting of most suitable curve using SPSS/R. Practical Work.
Week 8	Generation of random sample from different distributions and their graphic representation using SPSS/R. Practical Work.
Week 9	Importing and Exporting files in SPSS/R. How to deal with missing observations.
Week 10-12	Basics of Statistical inference for hypothesis testing, compute p-values and confidence interval. Testing of hypotheses: one sample t-test, paired sample t-test, Independent sample t-test using SPSS/R. Chi Square test for Goodness of Fit using SPSS/R. Practical Work.
Week 13-14	Constructing bivariate table and Chi Square test of Independence of attributes using SPSS/R. Practical Work.
Week 15	How to select a Simple random sample from a given population using SPSS/R. Practical Work.
Week 15	Code editing using syntax file in SPSS.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction to SPSS/R	Class room lectures and Practical work	Participation in class discussion and completion of assignment.
I	Exposure to the descriptive statistics and different types of graphs	Class room lectures and Practical work	Participation in class discussion and completion of assignment.
I	Generation of reports with detailed descriptive statistics	Class room lectures and Practical work	Participation in class discussion and completion of assignment. Formulation of null hypotheses analyse and interpret the results.
II	Understanding of the concept of different correlation coefficients		
II	Concept of lines of Regression		
III	Fitting of curves	Class room lectures and Practical work	Participation in class discussion and completion of assignment.
III	Generation of random numbers using different probability distributions		
IV	Sampling procedures	Project Work and its Presentation.	Identification of appropriate Test of Hypothesis, formulation of null hypothesis. Ability to analyse the data, interpret the result and draw conclusion.
IV	Understanding of Hypothesis Testing.		

B.Sc. (Programme) Mathematical Sciences

Semester-IV

SE 2: Statistical Computing using C

Credits: 4 **Marks: 100**

Course Objectives:

The learning objectives include:

- To understand computer programming and its roles in problem solving.
- To develop programming skills using the fundamentals and basics of C language.
- To enable effective usage of arrays, functions and pointers.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of C programming language.
- Various data types, operators, library functions, Input/Output operations.
- Decision making and branching and looping.
- Arrays.
- User defined functions, recursion functions.
- Storage class of Variables.

Unit I: C language: Structure of C program, Data type, Basic data types, Enumerated data types, Derived data types. Variable Declaration, Assignment of variables. Numeric, character, real and string constants. Different types of operators and expressions, Basic input/output. Standard header files, Library functions. String functions.

Unit II: Conditional statements, if…else, nesting of if...else, elseif ladder, switch statements, Loops in C: for, while, do... while loops, break, continue, exit( ), goto and label declarations.

Unit III: Arrays, Functions, classification of functions, functions definition and declaration, assessing a function, return statement. Parameter passing in functions, recursion in Functions.

Unit IV: Programs in C should be based on computational techniques in Statistics.

Suggested Readings:

1. Balagurusamy, E. (2011). Programming in ANSI C, 6th Ed, Tata McGraw Hill.
2. Forouzan, D.B.A. and Gilberg, R.F. (2007). Computer Science – A Structured Programming Approach Using C. 3rd Ed., Thompson Course Technology.
3. Gottfried, B.S. (1996). Schaum's Outline of Programming with C, 2nd Ed, McGraw Hill.
4. Kanetakar, Y. (2008). Let us C, BPB Publications.

Practical/Lab Work

List of Practicals:

1. Plot of a Graph of $y = f(x)$; $f(x) = x$, $f(x) = \exp(-x^2/2)$.
2. A Roots of a quadratic equation (with imaginary roots also).
3. Sorting of an array.
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. A Random number generation from Uniform, Exponential, Normal, Beta and Gamma distribution.
9. Matrix Addition, Subtraction, Transpose, Trace and Multiplication.
10. Fitting of binomial and Poisson distribution, goodness of fit.
11. Chi-square test goodness of fit.
12. Chi-square contingency table.
13. T-test for two means.
14. Paired t-test.
15. Multiple ad Partial correlation.
16. F-ratio test.
17. Rank Correlation (find Ranks also) without ties.
18. Fitting line of regression.

Week-wise Teaching Plan:

Week 1	Overview of C.
Week 2-3	Constants, Variables and Data Types.
Week 4-5	Operators and Expressions.
Week 6-7	Managing Input and Output Operations.

Week 8-9	Decision Making and Branching and develop programs to do statistical computing.
Week 10-11	Decision Making and Looping and run programs.
Week 12-13	Arrays. Develop programs to do statistical computing related to arrays, matrices etc.
Week 14-15	User Defined Functions and develop programs to do statistical computing using user defined functions, recursion.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The fundamental concepts of C programming language.	Class room lectures and discussions.	Participation in class discussion.
I	Various data types, operators, library functions, Input/ Output operations.	(i) Class room lectures and discussions. (ii) Solving of arithmetic expressions involving all types of operators.	(i) Participation in class discussion. (ii) Understanding the logic of expression solving hierarchy.
I	Decision making and branching and looping.	(i) Class room lectures and discussions. (ii) Writing of small program segments and solving exercise questions from suggested readings.	(i) Participation in class discussion. (ii) Understanding the logic of expression solving hierarchy with decision making and loops.
I	Arrays	(i) Class room lectures and discussions. (ii) Writing full statistical computing programs mentioned in the list of practical and running on Computer with data.	(i) Participation in class discussion. (ii) Ability to write full program with a dry run and error free program on computer.
I	User- defined functions,	(i) Class room lectures and	(i) Participation in class

	recursion functions. Storage class of Variables.	discussions. (ii) Writing full statistical computing programs mentioned in the list of practical and running on Computer with data.	discussion. (ii) Ability to write full program with a dry run and error free program on computer.
A*	Understanding basic concepts and writing of programs using arrays, user-defined functions etc.	Class Test/ Assignment work	Extent of clarity of theoretical concepts studied in the course.
B*	Ability to write and run complete error free program on computer.	Practical test on computers.	Practical handling of running understanding and rectifying errors in the program.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. (Programme) Mathematical Sciences

Semester-V

SEC- 3: Statistical Simulation

Credits: 4 **Marks: 100**

Course Objectives:

The learning objectives include:

- Concept of simulation and simulation modelling.
- Generation of Pseudo random number generators as well as from standard statistical distributions. Monte-Carlo simulation technique.
- Application of simulation techniques.

Course Learning Outcomes:

After completing this course, students will possess skills concerning:

- How simulation may be used to understand the behavior of real world systems by utilizing mathematical models with an emphasis on simulation.
- How to generate random numbers by the different methods.
- Hands-on experience in using simulation software packages/structured programming languages.

Unit I: Introduction: Need for simulation, general principles, simulation models, event type simulation.

Unit II: Random numbers generation: Pseudo random number generators; the inverse transform method, Discrete and Continuous distributions, Transformation of random variables.

Unit III: Applications of simulation: Monte Carlo simulation technique. Inventory problems, Queueing systems.

Unit IV: Advantages and disadvantages of simulation, simulation of languages, Scope of simulation technique.

Suggested Readings:

1. Fishman, G.S. (1996). Monte Carlo-Concepts, Algorithms and Applications, Springer.
2. Taha, H. A. (2010). Operations Research. An Introduction, 9th Ed, Pearson.
3. Reitman, J. (1971). Computer simulation Applications, John Wiley & Sons.

4. Swarup, K. Gupta, P.K. and Mohan, M. (2014). Operations Research, 15th Ed, Sultan Chand & Sons.
5. Payer T.A. (1982). Introduction to simulation, McGraw Hill.
6. Voss, J. (2013). An introduction to statistical computing: A simulation-based approach, 1st Ed., Wiley series in computational statistics.

Practical/Lab Work

List of Practicals:

1. Pseudo random number generators; Generation of $U(0,1)$.
2. The inverse transform method applied to standard statistical distributions (Discrete and Continuous).
3. Monte Carlo simulation methods.
4. Applications to Inventory Controls, Queueing systems, etc.

Week-wise Teaching Plan:

Week 1-2	Introduction to simulation, general principles, simulation models, broad overview.
Week 3-4	Pseudo random number generation methods. Practical Work.
Week 5-7	The inverse transform method; from discrete distributions. Practical Work.
Week 8-10	The inverse transform method; from continuous distributions. Practical Work.
Week 11-12	Monte Carlo simulation technique. Practical Work.
Week 13	Applications of simulation. Practical Work.
Week 14	Appraisal of simulation technique.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction: Need for simulation, general principles, simulation models, event type simulation.	Class room lectures and discussions.	Participation in class discussion.
II	Pseudo random number generators	(i) Class room lectures and	(i) Participation in class discussion.

	The inverse transform method; from discrete distributions. The inverse transform method; from continuous distributions	discussions. (ii) Practical work based on generation of random numbers.	(ii) Identification of random number, Monte-Carlo method, simulation worksheet, appropriate analysis, interpretation of results and conclusion.
A*	Understanding of basic concept of simulation and generation of random numbers.	Class Test/ Assignment work	Extent of clarity in theoretical concepts
III	Applications of simulation Monte Carlo simulation technique. Inventory problems, Queueing systems.	(i) Class room lectures and discussions. (ii)Practical work based on applications of simulation.	(i) Participation in class discussion. (ii) Identification of random number, Monte-Carlo method, simulation worksheet, appropriate analysis, interpretation of results and conclusion.
IV	Scope, Advantages and disadvantages of simulation.		
B*	Understanding of simulation in real life problems and scope of simulation in various fields of life.	Class Test/ Assignment work	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. (Programme) Mathematical Sciences

Semester-VI

SE-4: Statistical Techniques for Research Methods

Credits: 4 **Marks: 100**

Course Objectives:

The learning objectives include:

- To provide scientific approaches to develop the domain of human knowledge through the use of empirical data expressed in quantitative form.
- To enable the students to understand basic concepts and aspects related to research, various techniques to collect the data, analyse the data and interpret the results thereafter.

Course Learning Outcomes:

After completion of this course, students should have developed a clear understanding of:

- Research methodology.
- Research Problem.
- Research Designs.
- Comparative study of different methods of data collection.
- Guidelines for construction of questionnaires.
- Processing and Analysis of data.
- Interpretation and Report writing.

Unit I: Introduction: Meaning, objective and motivation in research, types of research, research approach, significance of research. Research problems: Definition, selection and necessity of research problems.

Unit II: Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, methods of data collection, non-response, questions and answers in surveys.

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

Unit IV: Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of

subsidy impact on service class v/s unorganized sectors), interpret the results and draw inferences.

Suggested Readings:

1. Cochran, W.G. and Cox, G.M. (1959). Experimental Design. Asia Publishing House.
2. Kothari, C.R. (2015). Research Methodology: Methods and Techniques, 3rd Ed., reprint, New Age International Publishers.
3. Kumar, R. (2011). Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.

Project Work (using spread sheet and statistical packages –SPSS/R)

Week 1	**Research Methodology:** Introduction, meaning of research, objectives of research, types of research, research approaches, research methods versus research methodology, research process. **Research Problem:** Importance and techniques involved in defining a research problem.
Week 2	**Research Design:** Important concepts relating to research design, different research design and basic principles of experimental design.
Week 3	**Design of Sample Surveys:** Census and sample survey, implications of a sample design, probability sampling, non-probability sampling. Practical Work- Introduction to a software package.
Week 4	**Methods Of Data Collection:** Primary and Secondary data, Collection of primary data, difference between questionnaires and schedules. Guidelines for constructing questionnaire and successful interviewing. Practical Work.
Week 5	**Data Preparation: Processing and Analysis of Data:** Processing Operations, measures of central tendency and dispersion. Practical Work.
Week 6	**Sampling Fundamentals:** Sampling and non-sampling errors, sampling distributions. Point and interval estimation. Practical Work.
Week 7	**Sampling Fundamentals:** Point and interval estimation. Sample size and its determination. Practical Work.
Week 8	**Testing of Hypothesis:** Basic concepts concerning testing of hypothesis**.** Test statistic, critical region, critical value and decision rule. Project Work.
Week 9	**Testing of Hypothesis:** Important Parametric Tests. Hypothesis testing of Means, and Proportions. Project Work /Practical Work.

Week 10	**Testing of Hypothesis:** Hypothesis testing for Difference between Means and Proportions. Project Work/ Practical Work.
Week 11	**Testing of Hypothesis:** Hypothesis testing for variance and equality of variances of two normal populations. Project Work/ Practical Work.
Week 12	**Chi-Square Tests:** Test of difference of more than two proportions, Test of Independence of Attributes. Project Work/ Practical Work.
Week 13	**Chi-Square Tests:** Test of Goodness of Fit. **Interpretation and Report Writing:** Meaning and technique of interpretation. Project Work/ Practical Work.
Week 14	**Interpretation and Report Writing:** Steps involved in report writing and its significance. Layout, mechanics and precautions for writing research reports. Submission of Project Work.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction to research methodology and technique of defining a research problem.	Class room lectures and discussions.	Participation in class discussion.
I	The basic principles of Experimental Designs and introduction to different research designs.	Class room lectures and discussions.	Participation in class discussion.
II	Concept of Sampling Designs	Class room lectures and discussions.	Participation in class discussion. Identification of a research problem.
II	Methods of Data Collection		
II	Guidelines for constructing Questionnaire and successful Interviewing		
II	Guidelines for constructing Questionnaire and successful Interviewing		
A*****	Understanding of fundamentals of research methodology, research	Class Test/ Assignment work	Extent of clarity in theoretical concepts

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
	problem and research designs.		
III	Understanding of Processing Operations.	Class room lectures and discussions.	(i) Participation in class discussion.
III	Descriptive and Inferential Analysis of data.		(ii) Development of a Questionnaire.
III	Sampling Distributions. Parametric Tests of Hypotheses. Chi -square Test.	Practical work using a software package.	Identification of appropriate Test of Hypothesis, formulation of null hypothesis, appropriate analysis, interpretation of results and conclusion.
B*****	Understanding of Hypothesis Testing.	Class Test/ Assignment work	Extent of clarity in theoretical concepts.
IV	Application of research methodology.	Project Work and its presentation.	Ability to analyse the data, interpret the result and draw conclusion.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. Programme Mathematical Sciences

Semester-V

DSE 1-(i): Vital Statistics

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- To collect valid Demographic data using different methods.
- To learn basic measures of Mortality, Fertility and Population Growth.
- To construct life tables.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Distinction between Vital Statistics and Demography.
- Errors in Demographic data.
- To check the completeness of registration data using Chandrasekaran-Deming formula.
- Use of Myer's and UN indices in evaluating age data.
- Use of Balancing Equations.
- Population Composition and Dependency Ratio.
- Sources of data collection on Vital Statistics and errors therein.
- Measurement of Population.
- Distinction between Rate and Ratio.
- Basic measures of Mortality.
- Concepts of Stable and Stationary Populations.
- Concept of Life Tables, their construction and uses.
- Basic measures of Fertility.
- Measures of Population Growth.

Unit I: Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekaran-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Unit II: 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.

Unit III: Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.

Unit IV: Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Suggested Readings:

1. Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9th Ed., World Press.
3. Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, F. E., Cowden, D. J. and Klein, S. (1973). Applied General Statistics, 3rd Ed. Prentice Hall of India Pvt. Ltd.
5. Keyfitz, N. and Beekman, J. A. (1984). Demogrphy through Problems, S-Verlag.

Practical/Lab Work

List of Practicals:

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 CBR, GFR, SFR, TFR for a given set of data.
6. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data.
7. Calculate GRR and NRR for a given set of data and compare them.

Week- wise Teaching Plan:

Week 1	Meaning of Demography and Population Statistics, Coverage and Content Errors in Demographic data, Use of Balancing Equations.
Week 2-3	Chandrasekran-Deming formula, Population Composition, Dependency

	Ratio. Errors in Age data, Evaluation of Age data, Myer's and UN Indices.
Week 4	Adjustment of Age data, Meaning of Vital Statistics, Vital events, Sources of data collection on Vital Statistics and errors they suffer from.
Week 5	Measurement of Population, Distinction between Rate and Ratio, Ratio of Vital events, Measures of Mortality: Crude Death Rate, Practical Work.
Week 6	Specific Death Rate, Standardized Death Rate, Direct and Indirect Methods of Standardization, Practical Work.
Week 7	Infant Mortality Rate, Relative Merits and Demerits of all the Rates. Practical Work.
Week 8-9	Concepts of Stable and Stationary Populations, Central Mortality Rate, Force of Mortality. Approximate expressions for Force of Mortality.
Week 10	Introduction to Life Tables, Life Table Functions and Columns, Assumptions in the construction of Life Tables, Various relationships in the columns of a life table.
Week 11	Construction of Life Tables, Uses of Life Tables, Introduction to the concept of Fertility, Difference between Fertility and Fecundity. Practical Work.
Week 12	Measures of Fertility: Crude Birth Rate, General Fertility Rate. Practical Work.
Week 13	Specific Fertility Rate, Total Fertility Rate, Relative merits and demerits of all the Rates. Practical Work.
Week 14-15	Measures of Population Growth: Crude Rate of Natural Increase, Pearl's Vital Index, Gross Reproduction Rate, Net Reproduction Rate, their relative merits and demerits. Practical Work.

Facilitating the achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Distinction between Vital Statistics and Demography.	Class room lectures and discussions.	Participation in class discussion.
I	Errors in Demographic data	Class room lectures and discussions.	Participation in class discussion.

I	To check the completeness of registration data using Chandrasekaran-Deming formula.	Class room lectures and discussions.	Participation in class discussion.
I	Use of Myer's and UN indices in evaluating age data.	Class room lectures and discussions.	Participation in class discussion.
I	Use of Balancing equations, Population Composition and Dependency Ratio	Class room lectures and discussions.	Participation in class discussion.
	Understanding of the basic concepts in Demographic analysis and to take care of errors in demographic data.	Class Test/Assignment Work	Depth of understanding in theoretical concepts.
II	Sources of data collection on Vital Statistics and errors therein.	Class room lectures and discussions.	Participation in class discussion.
II	Measurement of Population, Distinction between Rate and Ratio..	Class room lectures and discussions.	Participation in class discussion.
II	Basic measures of Mortality.	(i) Class room lectures and discussions. (ii) Practical work based on different measures of mortality.	Participation in class discussion.
	Understanding the primary sources of	Class Test/Assignment Work	(i) Depth of understanding in theoretical concepts.

	data collection on Vital events and learning some of the important measures of mortality.		(ii)Ability to choose appropriate measures of mortality in different situations with clear reasoning.
III	Concepts of Stable and Stationary Populations.	Class room lectures and discussions.	Participation in class discussion.
III	Concept of Life Tables, their construction and uses.	(i) Class room lectures and discussions. (ii) Practical work based on the construction of life tables.	Participation in class discussion.
	Learning the concept of Complete Life Tables and their construction.	Class Test/Assignment Work	Depth of understanding in theoretical concepts.
IV	Basic measures of Fertility. Measures of Population Growth.	(i) Class room lectures and discussions. (ii) Practical work based on different measures of fertility and population growth.	Participation in class discussion.
	Learning the basic measures of Fertility and Population growth.	Class Test/Assignment Work	(i) Depth of understanding in theoretical concepts. (ii) Ability to choose appropriate measures of fertility and population growth in different situations with clear reasoning.
	Application of the concepts learnt. (Optional)	Project Work/Presentation	Ability to apply the concepts learnt in real life.

B.Sc. (Programme) Mathematical Sciences

Semester-V

DSE1-(ii): Statistical Techniques for Quality Control

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- This course will help students to learn techniques and approach of SQC being used in industry to manufacture goods and services of high quality at low cost.
- This course will also give exposure to Sampling Inspection Plans.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- Statistical process control tools- Control charts for variables, attributes
- Statistical product control tools- Sampling inspection plans

Unit I: Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration.

Unit II: Statistical Process Control-Seven tools of SPC, chance and assignable causes of quality variation. Statistical Control Charts for variables: Construction and Statistical basis of 3-σ Control charts, analysis of patterns on control chart, Control charts for variables: X-bar & R-chart, X-bar & s-chart.

Unit III: Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

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

Suggested readings:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I & II, 8th Ed., The World Press, Kolkata.

2. Gupta S.C. and Kapoor V.K. (2014). Fundamentals of Applied Statistics. 4th Ed., Sultan Chand and Sons, New Delhi.

3. Montogomery, D. C. (2009). Introduction to Statistical Quality Control, 6th Ed., Wiley India Pvt. Ltd.

4. Mukhopadhyay, P. (2011). Applied Statistics, 2nd Ed. revised reprint, Books and Allied (P) Ltd.

5. Montogomery, D.C and Runger, G.C. (2008). Applied Statistics and Probability for Engineers, 3rd Ed. reprint, Wiley India Pvt. Ltd.

Practical/Lab Work

List of Practicals:

1. Construction of X-bar and R chart (without trial control limits).
2. Construction of X-bar and s chart (without trial control limits).
3. Construction of p-chart (fixed sample size).
4. Construction of p-chart (variable sample size).
5. Construction of d-chart.
6. Construction of c- chart.
7. Construction of u-chart.
8. Single sampling inspection plan.
9. OC functions and OC curves.
10. Determination of the best plan on the ASN.

Week-wise Teaching Plan:

Week 1-2	Introduction to quality, dimensions of quality, Its concept, application and importance. Historical perspective of quality control. Quality system and standards: Introduction to ISO quality standards, Quality registration.
Week 3-4	Process and product control, Seven tools of SPC, Chance and Assignable causes of quality variation. Examples of patterns on control chart.
Week 5-8	Statistical Control Charts- Statistical basis of 3-σ Control charts, Control charts for variables: X-bar & R-chart, X-bar & s-chart. Rational Sub-grouping, Revised and Modified Control Limits. Practical work

Week 9-12	Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability. Practical work
Week 13-15	Acceptance sampling plan: Principle of acceptance sampling plans. Single sampling plan with OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables. Practical work.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Introduction to Quality. Its concept, application and importance. Historical perspective of quality control. Introduction to ISO quality standards. Statistical process control tools, causes of variation.	(i) Class room lectures and discussions.	Participation in class discussion.
II / III	Statistical process control tools- Control charts for variables, attributes.	(i) Class room lectures and discussions. (ii) Practical problems from the list of practical.	Participation in class discussion. Problem solving, Analyse and Interpret the results.
II / III	Understanding basic concepts and control charts.	Class Test/ Assignment work	Extent of clarity of theoretical concepts studied in the course.
IV	Statistical product control tools- Sampling inspection plans, Dodge	(i) Class room lectures and	Participation in class discussion.

	and Roming plans.	discussions. (ii) Practical problems from the list of practical.	Problem solving, Analyse and Interpret the results.
A*	Understanding of complete course.	Class Test/ Assignment work.	Extent of clarity of theoretical concepts studied in the course.
B*	Application of statistical quality control. (optional).	Project Work and its presentation.	Ability to apply concepts of quality control, practical handling, understanding and giving solutions to a problem.

*As per requirements of Internal Assessment for B.Sc. (Programme).

B.Sc. (Programme) Mathematical Sciences

Semester-VI

DSE2-(i): Index Number and Time Series Analysis

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include:

- Understand the concept, formulation and application of index numbers.
- Understand the concept of time series, its components and their estimation.
- Application of time series.

Course Learning Outcomes:

After completing this course, students will possess the ability to appreciate, formulate solutions, analyze use of index numbers and time series to real world problems.

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

Unit II: Introduction to times series data, application of time series from various fields. Components of a times series, Decomposition of time series.

Unit III: Trend: Estimation of trend by free hand curve method, method of semi averages, fitting of various mathematical curves, and growth curves. Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series.

Unit IV: Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend. Ratio to Moving Averages and Link Relative method, Deseasonalization. Random Component: Variate difference method.

Suggested Readings:

1. Chatfield, C. (1980). The Analysis of Time Series: An Introduction, Chapman & Hall.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. II, 8th Ed., The World Press, Kolkata.
3. Gupta, S.C. and Kapoor, V. K. (2008). Fundamentals of Applied Statistics, 4th Ed. (reprint), Sultan Chand and Sons.

4. Kendall, M.G. (1976). Time Series, 2nd Ed., Charles Griffin and Co Ltd., London and High Wycombe.

5. Mukhopadhyay, P. (2011). Applied Statistics, 2nd Ed. Revised reprint, Books and Allied.

Practical/Lab Work

List of Practicals:

1. Calculate price and quantity index numbers using
   (i) Laspeyre's,
   (ii) Paasche's,
   (iii) Marshall-Edgeworth and
   (iv) Fisher's formulae.
2. To calculate the Chain Base index numbers for a given series of Fixed Base index numbers and show that the two are same.
3. To compute Chain Base index numbers for a given set of data.
4. To convert the Chain Base index numbers to Fixed Base index numbers.
5. Fitting and plotting of:
   (i) Modified exponential curve by method of three selected points,
   (ii) Gompertz curve by method of partial sums,
   (iii) Logistic curve by method of three selected points.
6. Fitting of trend by Moving Average Method (for both odd & even extent).
7. Measurement of Seasonal indices:
   (i) Ratio-to-Trend method
   (ii) Ratio-to-Moving Average method
   (iii) Link Relative method
8. Calculation of variance of random component by variate difference method.

Week-wise Teaching Plan:

Week 1-2	Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's. Practical Work.
Week 3-4	Edgeworth-Marshall and Fisher; Factor reversal and time reversal tests; Practical Work.
Week 5-6	Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers; Practical Work.

Week 6-7	Introduction to times series data, application of time series from various fields. Components of a times series, Decomposition of time series.
Week 8	Trend: Estimation of trend by free hand curve method, method of semi averages; Practical Work
Week 9-10	Fitting of various mathematical curves, and growth curves; Practical Work
Week 11-12	Method of moving averages. Detrending; Effect of elimination of trend on other components of the time series; Practical Work.
Week 13-14	Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend. Ratio to Moving Averages and Link Relative method, Deseasonalization; Practical Work.
Week 15	Random Component: Variate difference method; Practical Work.

Facilitating the achievement of Course Learning Outcomes:

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The concept of Index numbers, problems and their construction.	Class room lectures and discussions.	Participation in class discussion.
I	Various tests for good index numbers, chain base and consumer price index number.	(i) Class room lectures and discussions. (ii) Practical work.	Participation in class discussion.
II	Concept of time series and its applications.	(i) Class room lectures and discussions. (ii) Practical work.	(i) Participation in class discussion. (ii) Identification of different components of time series.
II	Components and decomposition of time series.		
A*	Understanding of concept of index numbers and time series.	Class Test/ Assignment work	Extent of clarity in theoretical/practical concepts
III	Estimation of trend by different methods and detrending.	(i) Class room lectures and discussions. (ii) Practical work based on estimation of different components of	(i) Participation in class discussion. (ii) Appraisal of different of estimation of trend, seasonal and random
IV	Estimation of seasonal component by different methods and Deseasonalization.		

IV	Random Component by Variate difference method.	time series.	components.
B*	Estimation of different components of time series by various methods, detrending and deseasonalization.	Class Test/ Assignment work	Extent of clarity in theoretical and practical concepts.

*As per requirements of Internal Assessment for B.Sc. (Programme)

B.Sc. (Programme) Mathematical Sciences

Semester-VI

DSE 2- (ii): Econometrics

Credits: 6 **Marks: 150**

Course Objectives:

The learning objectives include**:**

- To judge the validity of the economic theories
- To carry out evaluation of economic theories in numerical terms
- To extract useful information about important economic policy issues from the available data.

Course Learning Outcomes:

After completing this course, students should have developed a clear understanding of:

- The fundamental concepts of econometrics.
- Specification of the model.
- Simple Linear Regression.
- Multiple Linear Regression.
- Multicollinearity.
- Heteroscedasticity.
- Autocorrelation.

Unit I: Nature and Scope of Econometrics: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, interpretation of regression, nature and sources of data for econometric analysis, different measurement scales of variables.

Unit II: Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares, properties of estimators, goodness of fit, tests of hypotheses, scaling and units of measurement, confidence intervals, Gauss-Markov theorem and forecasting.

Unit III: Multiple Linear Regression: OLS Estimation of parameters; properties of OLS estimators, goodness of fit - R^2 , partial regression coefficients and testing of hypotheses on parameters (individual and joint).

Unit IV: Violations of Classical Assumptions: Multicollinearity- Concept, Consequences, Detection and Remedies. Heteroscedasticity and serial correlation– Concept and Consequences, goodness of fit - R^2, partial regression coefficients and testing of hypotheses on parameters

Suggested Readings:

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

Practical/Lab Work

List of Practicals:

1. Problems based on estimation of simple linear model.
2. Testing of parameters of simple linear model.
3. Multiple Regression.
4. Problems concerning specification errors.
5. Problems related to consequences of Multicollinearity.
6. Diagnostics of Multicollinearity.
7. Problems related to consequences Heteroscedasticity.
8. Diagnostics of Heteroscedasticity.
9. Estimation of problems of General linear model under Heteroscedastic distance terms.
10. Problems related to selection of best regression model.

Week-Wise Teaching Plan:

Week 1-2	Concept and methodology of econometrics.
Week 3	Concept of regression with examples.
Week 4	Terminology and the nature and sources of data for Economic analysis.
Week 5-6	Two Variable Case Estimation of model by method of ordinary least squares, properties of estimators, Gauss Markov Theorem. Practical work.
Week 7	Goodness of fit, tests of hypotheses, scaling and units of measurement, confidence intervals and forecasting. Practical work.

Week 8-9	OLS Estimation of parameters; properties of OLS estimators, goodness of fit. Practical work.
Week 10-11	Partial regression coefficients and testing of hypotheses on parameters (individual and joint). Practical work.
Week 12-13	Multicollinearity. Practical work.
Week 14	Heteroscedasticity. Practical work.
Week 15	Autocorrelation. Practical work.

Facilitating the achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	The fundamental concept of econometrics	Class room lectures and discussions	Participation in class discussion
I.	Specification of the model	Class room lectures and discussions	(i) Participation in class discussion (ii) Identification of models
II.	Simple linear regression	Class room lectures and discussion. Practical work based on two variable linear model	(i) Participation in class discussion. (ii) Interpretation of the estimated regression model
III	Multiple regression model	(i) Class room lectures and discussion. (ii) Practical Work based on three variable linear model.	(i) Participation in class discussion (ii) Interpretation of the estimated regression model.
A*	Understanding of basic concept of econometrics,	Class test / Assignment work	Extent of clarity in theoretical concepts

	estimation of parameters of regression models and their significance tests.		
IV	Multicollinearity	Classroom lectures and discussions Practical work	Participation in class discussion.
IV	Heteroscedasticity	Classroom lectures and discussions Practical work	Participation in class discussion. Understanding the nature of heteroscedasticity and its consequences.
IV	Auto correlation/ Serial correlation	Classroom lectures and discussions Practical work	Participation in class discussion Detection of autocorrelation in different models.
B*	Understanding the concepts related to violations of the classical assumptions of a general linear model.	Assignment work/ class test	Extent of clarity in theoretical concepts.

*As per requirements of Internal Assessment for B.Sc. (Programme).