Course outline for M.SC Statistics Semester 1st

S. No.	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	STA501C	Probability theory	4	4	0	0	0	4
2	STA502C	Sampling theory	4	4	0	0	0	4
4	STA503E	Descriptive Statistics	3	3	0	0	0	3
5	MTH501E	Linear Algebra	3	3	0	0	0	3
6	CSC502F	Introduction to Computers and Programming	4	3	0	2	0	5
7	ENG501F	Communication Skills	3	3	0	0	0	3
8	STA500C	Practical	2	0	0	4	0	4

Course Title: Probability Theory	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: STA501C	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The main objective of this course is to introduce the notion of probability, random variable, expectation, Law of Large Numbers and the Central Limit Theorem with their applications based on which statistical theory and tools have been developed.

Course Outcomes: After successful completion of this course, student will be able to:

1. Recall concept of probability and related terminology.
2. Differentiate discrete and continuous random variables and their distributions.
3. Understand probability mass function, density function and distribution function.
4. Compute expectations of random variables and their generating functions.
5. Learn the concepts of weak and strong laws of large numbers and central limit theorem.

Unit I: Basic definitions and ideas such as random experiment, sample space and event, Classical, relative frequency and Axiomatic definition of probability, Elementary properties of probability function, Probability inequalities such as Boole's inequality and Bonferroni inequality. Conditional probability and its basic properties, Examples of conditional probability and multiplication law, Theorem of total probability and related examples, Bayes theorem and related examples, Independent events, Sequences of events, Borel-Cantelli Lemma.

Unit II: Random variables and their distribution function, Induced probability space, Discrete and continuous random variables, Function of random variables (Discrete and Continuous), Expectation and moments (Raw, central and factorial) of random variables, Some Distributions and their Applications: Uniform (discrete and continuous), Bernoulli, Binomial, Poisson, Exponential and Normal.

Unit III: Random vectors and their joint distribution functions, Marginal distribution, Independent random variables, Conditional distribution of random vectors/variables, Expectation and moments of random vectors, Conditional Expectation, variance and covariance and their applications, Moment generating function, Probability generating function, Cumulant generating function, Characteristic function and their properties, Inversion, Continuity and Uniqueness theorems.

Unit IV: Markov, Chebyshev, Holder and Jensen's inequality, Idea of limiting distribution, Convergence in distribution and probability and related results, Convergence of moments and almost sure convergence, Various examples and counter examples, Weak and strong law of large numbers, Central limit theorem: Lindeberg–Levy, De-Mover's Laplace and Liapouloff's CLT, Applications, e.g., Continuous mapping theorem and delta method.

Textbooks/References:

1. Introduction to Probability, by Dimitri P. Bertsekas and John N. Tsitsiklis. Athena Scientific.
2. Probability – An Introduction, by Geoffrey Grimmett and Dominic Welsh, Oxford University Press.
3. Rao B. L. S. Prakasa (2009): A First course in Probability and Statistics. World Scientific.
4. John E Freund (2004): Mathematical Statistics with applications. 7/e, Upper saddle River, NJ: Prentice Hall. ISBN: 0131246461.
5. Rohatgi V.K & A.K. MD. Ehsanes Saleh (2001): An Introduction to Probability Theory and Mathematical Statistics, 2nd. John Wiley and Sons.

Course Title: Sampling Theory	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: STA502C	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Objective: The main objective is to provide the knowledge of concept of sample and population in statistics and also the various sampling schemes, Estimation of population parameters and their respective standard errors.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Recall necessity of sampling techniques.
2. Understand various types of sampling schemes, their advantages, disadvantages and estimation of population parameters.
3. Compare different sampling techniques.
4. Select appropriate sampling technique for different experimental scenario.
5. Conduct sample survey.

Unit I: Simple Random Sampling: Concept of sampling design, expected value and sampling variance of the sample mean, expected value of the sample mean square and estimation of the population variance, determination of sample size. Stratified Random Sampling: Estimation of the population mean/total and its variance, choice of sample sizes in different strata, variance under different allocation methods, comparison with unstratified sampling, estimation of the gain in precision due to stratification and construction of strata.

Unit II: Ratio and Regression Methods of Estimation: Variance of the estimates, estimation of variances, optimum property of ratio and regression estimators, ratio and regression estimators in stratified random sampling, some modifications of ratio and regression estimators, comparison among regression, ratio and simple unbiased estimators and unbiased ratio-type estimators.

Unit III: Systematic Sampling: Sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling in the general case as well as in the presence of a linear trend. Cluster Sampling: Cluster sampling with equal and unequal cluster sizes, relative efficiency with SRS and optimum cluster size.

Unit IV: Double Sampling: Double sampling for stratification including estimation of variance, variance of ratio and regression estimates in double sampling, double sampling for probability proportional to size (PPS) estimation. Sampling on Successive Occasions: Sampling on two occasions and estimation of current population mean. Two-Stage Sampling: (a) Equal first-stage units – estimation of population mean and its variance and estimates of variance; comparison with one-stage sampling. (b) Unequal first-stage units – estimation of population mean; expected values and variances of different estimators, including the case of probability proportional to size.

Textbooks/References:

1. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
2. Cochran, W. G: Sampling Techniques, 3rd edition, John Wiley and Sons.
3. Mukhopadhyay, P. (2000): Theory and Methods of Survey Sampling, Prentice Hall of India, Private limited, New Delhi.
4. S.C. Gupta and V.K. Kapoor (1984): Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi.
5. Singh, D and Chaudhary, F. S. (1986): Theory and Analysis of Sample Survey Design, New Age International Publisher.

Course Title: Descriptive Statistics	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: STA503E	**3**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 3					

Objective: The main objective of this paper is to make students understand descriptive statistical methods for doing statistical analysis

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Understand the fundamental concepts and scope of descriptive statistics and its role in data analysis.
2. Develop skills in organizing, summarizing, and presenting data through tabular, diagrammatic, and graphical methods.
3. Comprehend and apply various measures of central tendency, dispersion, skewness, and kurtosis for data interpretation.
4. Learn the construction and interpretation of different types of index numbers, including price, quantity, and value indices.
5. Apply descriptive statistical tools to analyze real-life data and draw meaningful conclusions.

Unit I: Statistics a conceptual frame work, statistical enquiry, collection of data, classification and tabulation of data, diagrammatic and graphic presentation of data. Measures of Central Tendency: Mean, median, mode, geometric mean and harmonic mean, characteristics of a good average.

Unit II: Measures of Dispersion: Range, mean deviation, quartile deviation, standard deviation and coefficient of variation, moments. Measures of skewness: Karl Pearson’s and Bowley's methods, measures of kurtosis, Sheppard’s corrections.

Unit III: Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre’s, Paasche’s, Edgeworth-Marshall and Fisher’s, chain index numbers, conversion of fixed based to chain based index numbers and vice-versa, consumer price index numbers, whole sale price index.

Textbooks/References:

1. Bhat, B.R., Srivenkatramana, T. and Rao Madhava K. S : *Statistics: A Beginner’s Text,* New Age International (P) Ltd**.**
2. Croxton F. E, Cowden D.J and Kelin S : *Applied General Statistic,* Prentice Hall of India.
3. Gupta, S. C. and Kapoor, V. K.: *Fundamentals of applied Statistics*. Sultan Chand and sons.
4. S. P. Gupta: Statistical Methods. Sultan Chand and sons.
5. Elhance, D. N., Veena Elhance & Aggarwal B. M.: *Fundamentals of Statistics* , Kitab Mahal.

Course Title: Linear Algebra	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: MTH501E	**3**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 3					

Objective: The main purpose is to provide mathematical foundation for statistics courses to enhance their knowledge in Linear algebra.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Students will develop a thorough understanding of fundamental linear algebra topics such as vector spaces, matrices, determinants, eigenvalues and eigenvectors, which are required for further studies in mathematics and related subjects.
2. Students will master key operations such as matrix multiplication, row reduction and discovering inverses as well as how to solve systems of linear equations which will help them improve their problem-solving and analytical skills.
3. Students will be able to apply linear algebra concepts to real-world issues in physics, engineering, computer science, economics and other subjects, illustrating the subject's widespread relevance and usefulness.

Unit I: Introduction to systems of linear equations, matrices and matrix operations, transpose and adjoint of a matrix, inverses, diagonal, triangular and symmetric matrices, determinants, cofactor expansion, row reduction, Gauss-Jordan elimination.

Unit II: Euclidean n-space, vector spaces and subspaces, linear transformations on n-spaces, linear independence, basis and dimension, row space, column space, null space, rank and nullity, change of basis, inner products, orthogonality, orthonormal bases, Gram–Schmidt process and orthogonal transformations.

Unit III: Eigenvalues and eigenvectors, algebraic and geometric multiplicities of eigenvalues, Cayley–Hamilton theorem, diagonalization and orthogonal diagonalization, real quadratic forms, reduction and classification of quadratic forms.

Textbooks/References:

1. Linear Functions and Matrix Theory by Bill Jacob
2. A Textbook on Matrices by Hari Krishen
3. Linear Algebra – Schaum’s Outline Series
4. Linear Algebra and its Applications by David C. Lay, Springer
5. Linear Algebra and its Applications by Gilbert Strang Thomson Learnin

Course Title: Introduction to Computers and Programming	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: CSC502F	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The course introduces students to the fundamentals of computers and programming. It emphasizes basic computer organization, operating systems, and programming principles with Python, enabling students to develop problem-solving skills and computational thinking required for statistical applications.

Course Outcomes: By the end of the course, students will be able to:

1. Explain the fundamentals of computers, operating systems and programming environments.
2. Write structured Python programs using variables, control structures and functions.
3. Apply arrays, strings and file-handling techniques for solving computational problems.
4. Use Python programming for simple data handling and statistical problem-solving.

Unit I: Fundamentals of Computers: Introduction to computers; overview of computer organization: CPU, memory, input/output devices; Number systems (binary, octal, hexadecimal) and conversions; Data representation: integers, floating-point, characters; Introduction to operating systems.

Unit II: Introduction to Programming Concepts: Algorithms and flowcharts, examples; Introduction to programming languages; Introduction to Python: features, installation, Jupyter Notebook/IDLE; Writing and executing Python scripts; Variables, constants, expressions, data types, type conversion, input/output operations.

Unit III: Control Structures and Functions: Decision-making and looping: if, if-else, nested if, for, while loops; Break, continue, pass statements; Functions: definition, arguments, return values, scope of variables, recursion; Built-in functions and modules; Exception handling basics.

Unit IV: Data Structures and File Handling in Python: Strings, lists, tuples, sets, dictionaries: creation, operations and applications; Arrays using NumPy: creation, indexing, slicing; File handling: text and CSV files – read, write, append; Introduction to simple problem-solving in statistics (mean, variance, correlation) using Python.

List of Practical's

1. Writing and executing simple Python programs (basic syntax, input/output).
2. Programs using operators and expressions.
3. Programs using conditional statements (if, if-else, nested if).
4. Programs using loops (for, while, nested loops).
5. Defining and invoking functions with parameters and return values.

6. Programs on recursion and exception handling.
7. String manipulation and list operations in Python.
8. Programs using dictionaries, sets, and tuples.
9. Reading from and writing to text and CSV files.
10. Introduction to NumPy arrays and simple computations.
11. Computing mean, variance, and correlation using Python.

Textbooks/References

1. Reema Thareja, *Python Programming: Using Problem Solving Approach*, Oxford University Press.
2. E. Balagurusamy, *Fundamentals of Computers*, McGraw Hill.
3. John Zelle, *Python Programming: An Introduction to Computer Science*, Franklin, Beedle & Associates.
4. Allen B. Downey, *Think Python: How to Think Like a Computer Scientist*, O'Reilly.

Online Resources

1. https://docs.python.org – Official Python Documentation
2. https://numpy.org – NumPy for array computing
3. https://www.w3schools.com/python – Python tutorials
4. https://realpython.com – Python guides and examples

Course Title: Communication Skills	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: ENG501F	**3**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 3					

Course Objective: The aim of this course is to introduce the students an overview of prerequisites to business and organizational communication.

Course Outcomes: After the completion of this course, students shall be able to

1. Develop proficiency in English language skills, including vocabulary enrichment, correct usage of tenses, reported speech, concord, articles and word formation.
2. Demonstrate the ability to apply technical writing principles in preparing clear, concise and structured reports, proposals and research papers while avoiding plagiarism.
3. Analyze and compose effective business correspondence, including letters, emails, CVs/resumes and cover letters, tailored to the audience and purpose.
4. Enhance communication skills necessary for professional and organizational contexts, with a focus on clarity, accuracy and appropriateness of language.
5. Apply critical thinking and language skills to produce well-structured written documents for academic, technical and business purposes.

Unit I: Introduction to phonetic sounds and transcription of words, enriching vocabulary, word formation: prefixes and suffixes, homophones, antonyms, synonyms, idioms and phrases, one word substitution, tenses, reported speech, concord, articles.

Unit II: Characteristics of technical writing, difference between technical writing and general writing, essentials of strong writing skills, report writing: structure, style and drafting of different types of reports, proposal writing, writing research papers, avoiding plagiarism.

Unit III: Ramifications of business letters, analyzing audience and purpose, layout and format, types of business letters; CV/resume writing and cover letters.

Textbooks/References:

1. Battacharaya, Indrajit. An Approach to Communication Skills. New Delhi: Dhanpat Rai and Co, 2002.
2. Chaturvedi, P.D and Mukesh Chaturvedi. Business Communication, Delhi: Pearson Education, 2006.
3. Mohan, Krishna and Meera Bannerji. Developing Communication Skill, Delhi: Macmillian, 1990.
4. Raman, Meenakshi and Sangeeta Sharma. Technical Communication: Principles and Practice. India: OUP, 2011.
5. Roach, Peter. English Phonetics and Phonology. London: Cambridge University Press, 2000.

Course Title: Practical	**L**	**T**	**P**	**S**	**Semester:** Ist
Course Code: STA500C	**x**	**x**	**4**	**x**	**Max Marks**: 50
Credits: 2					

Course Objective: The main objective is to enhance the practical knowledge of the students in the courses sampling theory and probability theory.

Course Outcome: Upon successful completion of this course, the student will be able to:

1. Apply statistical computation techniques using any statistical software for problems related to Sampling Theory and Probability Theory.

Practical Exercises: Practical work will be based on courses STA501C (Sampling Theory) and STA502C (Probability Theory).