Re-Accredited 'B++' 2.86 CGPA by NAAC
VEER NARMAD SOUTH GUJARAT UNIVERSITY
University Campus, Udhna-Magdalla Road, SURAT - 395 007, Gujarat, India.
વીર નર્મદ દક્ષિણ ગુજરાત યુનિવર્સિટી
યુનિવર્સિટી કેમ્પસ, ઉધના-મગદલ્લા રોડ, સુરત - ૩૯૫ ૦૦૭, ગુજરાત, ભારત.
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ક્રમાંકઃઓથો./પરિપત્ર/૧૩૬૫૬/૨૦૨૬
તા.૧૯/૦૬/૨૦૨૬

પ્રતિ,
વડાશ્રી,
સ્ટેટિસ્ટિક્સ ડિપાર્ટમેન્ટ,
વીર નર્મદ દક્ષિણ ગુજરાત યુનિવર્સિટી,
સુરત.

વિષયઃ– NEP-2020 અંતર્ગત શૈક્ષણિક વર્ષ ૨૦૨૬–૨૭ થી અમલમાં આવનાર M.Sc. Statistics Sem.-1 & 2 ના અભ્યાસક્રમના બાબત.

સુજ્ઞશ્રી,

સવિનય જણાવવાનું કે, NEP-2020 અંતર્ગત શૈક્ષણિક વર્ષ ૨૦૨૬–૨૭ થી અમલમાં આવનાર 2 Year PG - M.Sc. Statistics Sem.-1 & 2 નો આંકડાશાસ્ત્ર વિષયની અભ્યાસ સમિતિની તા.૧૮/૦૯/૨૦૨૫ ની સભાના ઠરાવ ક્રમાંકઃ૦૫ થી નિમણૂંક કરેલ પેટાસમિતિ દ્વારા તૈયાર કરવામાં આવેલ અભ્યાસક્રમ આંકડાશાસ્ત્ર વિષયની અભ્યાસ સમિતિના ચેરમેનશ્રીએ અભ્યાસ સમિતિવતી મંજૂર કરી વિજ્ઞાન વિદ્યાશાખાને કરેલ ભલામણ વિજ્ઞાન વિદ્યાશાખાની તા.૦૪/૦૬/૨૦૨૬ ની સભાના ઠરાવ ક્રમાંકઃ૩૯ થી મંજૂર કરવા એકેડેમિક કાઉન્સિલને કરેલ ભલામણ એકેડેમિક કાઉન્સિલની તા.૧૮/૦૬/૨૦૨૬ ની સભાના ઠરાવ ક્રમાંકઃ૨૭ થી મંજૂર કરેલ છે. જેનો અમલ કરવા આથી જાણ કરવામાં આવે છે.

(બિડાણઃ ઉપર મુજબ)

કુલસચિવ

પ્રતિ,
(૧) અધ્યક્ષશ્રી, વિજ્ઞાન વિદ્યાશાખા,
(૨) પરીક્ષા નિયામકશ્રી, પરીક્ષા વિભાગ, વીર નર્મદ દ. ગુ. યુનિવર્સિટી, સુરત.

.....જાણ સારૂ.

VEER NARMAD SOUTH GUJARAT UNIVERSITY, SURAT
SYLLABI OF
M. Sc. (STATISTICS) Course-Work
As per NEP 2020
To be implemented from the Academic Year 2026-27
UNDER THE FACULTY OF SCIENCE

Name of Program	Master of Science in Statistics (Only Course-work)
Program Abbreviation	M. Sc. Statistics (Only Course-work)
Duration	2 years
Eligibility Criteria	(1) A Students is eligible for the M. Sc. (statistics) program under the Faculty of Science if Statistics/Applied Statistics/ Data Science/ Dada Analytics has been studied as a major/ principal, or Mathematics as a major/principle subject and Statistics/Applied Statistics/ Data Science/ Data Analytics as a minor/ subsidiary in the B. Sc. Program. (2) Admission will be based on the student's performance in the B. Sc. Program. Regardless of the major/ principal or minor/ subsidiary subject/ discipline chosen in the UG program, a student is eligible for admission to the M. Sc. (Statistics) program under the Faculty of Science if they qualify the university-level entrance examination, provided that there are available seats after the admissions based on the criteria in point (1). Admission will be based on the student's performance in the university-level entrance examination.
Pre-requisite	Applicants seeking admission to the M. Sc. (Statistics) programme should have a basic foundation in Statistics and Mathematics at the undergraduate level, including knowledge of probability, statistical methods, data analysis, algebra, and calculus. Familiarity with statistical software tools is desirable. Candidates fulfilling the prescribed eligibility criteria or qualifying through the university-level entrance examination may be considered for admission as per university rules.
Medium of Instruction	English
Objective of Program	**Main Objectives are:** ➢ To provide advanced knowledge of statistical methods and applications. ➢ To develop analytical and data interpretation skills. ➢ To train students in statistical computing and modern software tools. ➢ To prepare students for research, higher studies, and professional careers in statistics and data analytics.
Program Outcome (PO)	**PO-01: Advanced Knowledge & Conceptual Understanding:** Demonstrate in-depth knowledge of core principles and emerging trends in the chosen scientific discipline. Integrate multidisciplinary scientific concepts to address real-world challenges in research and industry. **PO-02: Research & Analytical Skills:** Develop critical thinking, problem-solving and research-oriented skills for innovation and scientific advancements. Apply modern experimental,

	computational and statistical tools for data analysis and evidence-based conclusions. **PO-03:** **Technological Proficiency & Instrumentation:** Gain expertise in advanced laboratory techniques, computational modelling and high-end scientific instrumentation. Utilize cutting-edge technologies such as artificial intelligence, bioinformatics and nanotechnology for scientific exploration. **PO-04:** **Environmental & Societal Impact:** Understand the role of science in addressing environmental sustainability, public health and resource management. Contribute to biodiversity conservation, sustainable agriculture and climate change mitigation through scientific solutions. **PO-05:** **Innovation & Entrepreneurship:** Apply scientific knowledge for the development of innovative products, processes and services in industry & start-ups. Promote entrepreneurship in science and technology, healthcare, analytics and environmental sciences through technology transfer. **PO-06:** **Communication & Collaborative Research:** Develop proficiency in scientific communication, technical writing and effective dissemination of research findings. Engage in interdisciplinary collaborations, industry-academic partnerships and global research networks. **PO-07:** **Ethical & Value-Based Scientific Practices:** Uphold scientific integrity, ethical research practices and social responsibility in professional and academic endeavours. Apply knowledge with a strong ethical framework, considering societal, legal and environmental implications. **PO-08:** **Lifelong Learning & Career Readiness:** Cultivate a mind-set for lifelong learning, professional growth and adaptability to new scientific developments. Prepare for higher education, research careers, competitive exams and industry-oriented roles in science and technology.
Program Specific Outcomes (PSO)	**PSO-01:** Demonstrate advanced knowledge and conceptual understanding of statistical theories, probability distributions, estimation techniques, testing of hypotheses, linear models, multivariate analysis and mathematical foundations including real analysis and linear algebra for solving complex statistical problems. **PSO-02:** Apply statistical, computational and programming skills using modern tools and software such as Excel, JAMOVI, C, Python and R for data management, visualization, modeling, simulation and interpretation of data-driven problems in research, industry and governance. **PSO-03:** Design and conduct statistical investigations using sampling techniques, design of experiments, econometric models, stochastic processes and operations research methodologies to generate evidence-based conclusions and innovative solutions.

PSO-04: Utilize statistical methodologies in interdisciplinary domains such as healthcare, clinical research, official statistics, actuarial science, industrial statistics, business analytics, environmental studies and public policy for addressing real-life challenges.

PSO-05: Develop competency in data mining, statistical simulation, predictive analytics and emerging computational approaches including artificial intelligence-assisted statistical analysis for handling large and complex datasets.

PSO-06: Apply statistical practices with scientific integrity, ethical standards and social responsibility while ensuring accuracy, transparency, confidentiality and sustainability in data collection, analysis and reporting.

PSO-07: Demonstrate effective scientific communication, technical writing, presentation and collaborative skills required for multidisciplinary research, academic activities, industrial projects and professional teamwork.

PSO-08: Develop professional competence, entrepreneurial abilities and lifelong learning skills for careers in academia, research organizations, government sectors, industries, analytics firms, financial institutions and competitive examinations, while adapting to evolving advancements in statistics and data science.

Mapping between POs and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
PO1	✓	✓	✓					✓
PO2	✓	✓	✓	✓	✓		✓	✓
PO3		✓	✓		✓			✓
PO4				✓		✓		✓
PO5		✓	✓	✓	✓		✓	✓
PO6			✓	✓		✓	✓	✓
PO7				✓		✓	✓	✓
PO8	✓	✓	✓	✓	✓	✓	✓	✓

Structure of Credit Frame Work as per NEP 2020
AFTER U. G. (3 Years) – P. G. – General –M. Sc. (Statistics) – Only Course Work
[1] – A TWO-YEAR PG WITH COURSE WORK ONLY – SEMESTER-(22 Credits) – SEM- I
Structure of Credit Frame Work as per NEP 2020

Course Category	Course Code	Course Title	Mark sheet Title in English	Level of Course	Teaching Hours/Week		Exam Duration $		Credit		Internal Marks		External Marks		Total Marks	
					TH	PR*	TH	PR*	TH	PR*	TH	PR*	TH	PR*	TH	PR*
Major-1	ST-1001	Real Analysis	Real Analysis	400-499	02	-	01	-	02	-	25	-	25	-	50	-
Major-1	STP-1001	Real Analysis	Real Analysis	400-499	-	04	-	04	-	02	-	25	-	25	-	50
Major-2	ST-1002	Probability Theory	Probability Theory	400-499	02	-	01	-	02	-	25	-	25	-	50	-
Major-2	STP-1002	Probability Theory	Probability Theory	400-499	-	04		04		02		25		25		50
Major-3	ST-1003	Linear Algebra	Linear Algebra	400-499	02	-	01	-	02	-	25	-	25	-	50	-
Major-3	STP-1003	Linear Algebra	Linear Algebra	400-499	-	04	-	04	-	02	-	25	-	25	-	50
Major-4 (BKS)	ST-1004	Indian Statistical Knowledge System	Indian Statistical Knowledge System	500-599	04	-	02	-	04	-	50	-	50	-	100	-
Multidisciplinary	ST-1005	Database Management System	Database Management System	500-599	02	-	01	-	02	-	25	-	25	-	50	-
	STP-1005	Database Management System	Database Management System	500-599	-	04	-	04	-	02	-	25	-	25	-	50
		MOOC Course	MOOC Course	500-599	-	-	-	-	4		-	-	-	-	-	-
Skill Enhancement Course	ST-1006	Statistical Computing with Excel & JAMOVI	Statistical Computing with Excel & JAMOVI	500-599	2		01		2		25		25		50	
Total Hours For Students:					= 30											
Total Hours For the Department:					= 12 hrs Fixed for theory paper + 18 hrs/batch of practical & skill enhancement											

NOTE: * (1) Maximum Batch size for practical be 10-15 students as per NEP 2020 guidelines
(2) For practical examinations maximum 10 students will be allotted to one examiner per batch per session per course
(3) Exam of Skill Enhancement course be taken on computers
(4) $ Exam duration will be as per university circular.

[Subject code for Theory-2603083101011001]

[Subject code for Practical-2603083101011002]

Major – 1 M. Sc. (Statistics) Semester I Course: ST-1001 Real Analysis						
Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development					
Subject Type	Discipline Specific					
Course Code	ST-1001					
Course Level	400-499					
Course Title	Real Analysis					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					
Course Outcomes						

CO-01:	Demonstrate in-depth understanding of the real number system including Archimedean property, countable and uncountable sets, supremum and infimum, as foundational knowledge for advanced statistical theory.
CO-02:	Develop rigorous understanding of metric spaces, sequences, series, Cauchy convergence, compactness, completeness, and connectedness required for advanced statistical inference and probability.
CO-03:	Apply concepts of classes of sets, sigma-fields, Borel sets, measurable spaces, and measurable functions to formalize probability spaces and statistical models.
CO-04:	Construct rigorous mathematical proofs and analytical arguments involving measure theory, Caratheodory extension, and Lebesgue–Stieltjes measures, ensuring readiness for GSET and UGC NET Statistics.
CO-05:	Apply Lebesgue integration, dominated convergence, monotone convergence, and Fatou's lemma to evaluate integrals arising in probability distributions and statistical inference.
CO-06:	Analyze absolute continuity, singularity of measures, Radon–Nikodym theorem, and Lebesgue decomposition, and relate these to likelihood-based inference and change-of-variable techniques.
CO-07:	Implement computational tools such as Excel and JAMOVI to verify analytical results, visualize convergence behaviour, and simulate measure-theoretic concepts.
CO-08:	Communicate mathematical reasoning and analytical findings effectively and conduct independent study with scientific ethics and

		professional responsibility, preparing for research and competitive examinations.
Course Content	**Unit-1**	**Foundations of Real Analysis and Measurable Spaces** • Real number system as a complete ordered field; Archimedean property, denseness of rationals and irrationals. • Countable and uncountable sets, cardinality; supremum, infimum, and the completeness axiom. • Sequences and series of real numbers: convergence, divergence, subsequences, and limit superior/inferior. • Cauchy sequences, Cauchy criterion for convergence; monotone convergence theorem for sequences. • Functions of a real variable: limits, continuity, uniform continuity, and differentiability. • Metric spaces: definition, open and closed sets, interior, closure and boundary; compactness (Heine-Borel theorem), completeness, and connectedness. • Classes of sets: semi-rings, rings, fields (algebras), σ-rings, σ-fields (σ-algebras), and monotone classes. • Generated σ-fields; Borel σ-fields on R and R^{ε} and their properties. • Measurable spaces and measurable functions; simple functions and their properties. • Borel measurable functions; pointwise limits and measurability. • Modes of convergence: almost everywhere (a.e.), in measure, in mean; inter-relationships and counterexamples.
	Unit-2	**Measure Theory and Integration** • Finitely additive and σ-additive set functions; signed measures and total variation. • Measures and their properties: monotonicity, continuity from above and below, subadditivity. • Outer measures and the Caratheodory Extension theorem (statement and construction). • Construction of Lebesgue measure on R; Lebesgue measurable sets and non-measurable sets (existence). • Lebesgue–Stieltjes measure through distribution functions; product measures and Fubini's theorem (statement). • Integration of non-negative measurable functions and simple functions with respect to a measure. • Properties of Lebesgue integrals: linearity, monotonicity, and absolute continuity of integral. • Monotone Convergence theorem, Fatou's Lemma, and Dominated Convergence theorem with statistical applications. • Absolute continuity and singularity of measures; Lebesgue Decomposition theorem. • Radon–Nikodym theorem: statement, proof sketch, and applications to probability densities and likelihood functions. • L^p spaces: definitions, completeness (Riesz-Fischer theorem), different moment inequalities.
Corse Code	STP-1001	
Course Title	Practical in Real Analysis	

Course Practical Content

1. Exploring the Real Number System
2. Convergence and Divergence of Sequences
3. Cauchy Sequences and Convergence Criterion
4. Limit Superior, Limit Inferior, and Subsequence's
5. Continuity and Uniform Continuity
6. Classes of Sets and Sigma-Fields
7. Measurable Functions and its applications
8. Modes of Convergence and its applications
9. Lebesgue Measure of Intervals and Step Sets
10. Numerical Lebesgue Integration using Simple Functions
11. Verification of Convergence Theorems – Monotone Convergence and Dominated Convergence
12. Absolute Continuity and the Radon–Nikodym Derivative
13. Lebesgue–Stieltjes Integration and Computation of Expectations
14. L^p Norms and Inequalities

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓							
CO2	✓	✓						
CO3	✓				✓			
CO4	✓							✓
CO5	✓	✓		✓				
CO6	✓	✓						
CO7			✓			✓		
CO8							✓	✓

Reference Books

1. Athreya, K. B., & Lahiri, S. N. (2006). Measure Theory and Probability Theory. New York: Springer. ISBN: 978-0387329031.
2. Billingsley, P. (2012). Probability and Measure (4th ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1118122372.
3. Casella, G., & Berger, R. L. (2002). Statistical Inference (2nd ed.). Pacific Grove, CA: Duxbury Press. ISBN: 978-0534243128.
4. Chung, K. L. (2001). A Course in Probability Theory (3rd ed.). San Diego, CA: Academic Press. ISBN: 978-0121741518.
5. Durrett, R. (2019). Probability: Theory and Examples (5th ed.). Cambridge: Cambridge University Press. ISBN: 978-1108473682.
6. Feller, W. (1968). An Introduction to Probability Theory and Its Applications (Vols. I & II, 3rd ed.). New York: John Wiley & Sons. ISBN: 978-8126518050.
7. Gut, A. (2013). Probability: A Graduate Course (2nd ed.). New York: Springer. ISBN: 978-1461447061.
8. Hogg, R. V., McKean, J. W., & Craig, A. T. (2018). Introduction to Mathematical Statistics (8th ed.). Boston: Pearson Education. ISBN: 978-0134686998.
9. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). New York: McGraw-Hill. ISBN: 978-0070431744.
10. Resnick, S. I. (2014). A Probability Path. New York: Birkhäuser. ISBN: 978-0817639242.
11. Rohatgi, V. K., & Saleh, A. K. M. E. (2015). An Introduction to Probability and Statistics (3rd ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1118799680.
12. Ross, S. M. (2014). A First Course in Probability (9th ed.). Boston: Pearson Education. ISBN: 978-0321794772.
13. Shiryaev, A. N. (2016). Probability (2nd ed.). New York: Springer. ISBN: 978-1493932386.

		NPTEL / Online Resources
	14.	NPTEL Course: Real Analysis (IIT level) – available at nptel.ac.in
	15.	SWAYAM MOOCs on Mathematical Analysis and Probability – available at swayam.gov.in
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments	
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks	

[Subject code for Theory-2603083101022001]
[Subject code for Practical-2603083101022002]

Major – 2
M. Sc. (Statistics) Semester I
Course: ST-1002 Probability Theory

Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development					
Subject Type	Discipline Specific					
Course Code	ST-1002					
Course Level	400-499					
Course Title	Probability Theory					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Demonstrate comprehensive understanding of probability spaces, sigma-fields, random variables, distribution functions, and their Lebesgue decomposition as mathematical foundations for advanced statistical theory.
CO-02:	Apply classical probability inequalities — Markov, Chebyshev (one-sided and two-sided), Jensen, Cauchy–Schwarz, Hölder, and Minkowski — to derive statistical bounds and solve GSET/UGC NET problems.
CO-03:	Analyse characteristic functions, MGFs, inversion theorem, uniqueness theorem, and continuity theorem; apply these to identify distributions and establish limit theorems.
CO-04:	Develop rigorous understanding of modes of convergence (a.s., in probability, in distribution, in rth mean), Borel–Cantelli lemma, Kolmogorov zero–one law, LLN, and CLT for asymptotic statistical theory.
CO-05:	Implement Excel and JAMOVI to simulate, visualise, and numerically verify probability theorems, inequalities, convergence behaviour, and limiting distributions.
CO-06:	Apply probability theory in interdisciplinary contexts — actuarial science, Bayesian inference, survey sampling, data science, and environmental modelling — promoting innovation in statistics-based industries.
CO-07:	Construct mathematical proofs involving characteristic functions, independence, tail sigma-fields, Kolmogorov inequality, and CLT, ensuring readiness for GSET and UGC NET Statistics.
CO-08:	Cultivate ethical scientific practice, effective communication, and lifelong learning through seminars, SWAYAM/NPTEL engagement, collaborative projects, and competitive examination preparation.

Course Content	**Unit-1**	**Foundations of Probability and Distribution Theory** • Probability spaces (Ω, $\mathscr{F}$, P): sample space, events, sigma-fields, probability measure; properties — monotonicity, sub-additivity, continuity from above and below, inclusion-exclusion. • Random variables and random vectors: measurability, Borel measurability, and induced probability measures. • Distribution functions and joint distribution functions: properties, marginals, and correspondence with probability measures. • Types: discrete (PMF), absolutely continuous (PDF), and singular distributions; Lebesgue decomposition of distribution functions. • Mathematical expectation: definition via Lebesgue integration; moments, central moments, skewness, kurtosis; MGF and cumulant generating functions. • Characteristic functions: definition, properties (continuity, positive-definiteness, boundedness, uniqueness), and examples for Binomial, Poisson, Normal, Exponential, and Uniform distributions. • Inversion theorem, uniqueness theorem, and continuity theorem (Lévy) — statements, interpretations, and statistical implications. • Classical inequalities with applications: Markov, Chebyshev (both forms), Jensen (convex functions), Cauchy–Schwarz, Hölder, and Minkowski inequalities. • Stochastic independence: independent events, independent classes, independent random variables; multiplication theorem. • Borel–Cantelli lemma (first and second parts) and Borel zero–one law with applications. • Conditional probability and conditional expectation: existence (Radon–Nikodym), Tower property, law of total variance. • Weak convergence of distribution functions: Helly's theorem, Helly–Bray theorem, tightness, and weak compactness.
	Unit-2	**Convergence Concepts and Limit Theorems** • Sequences of random variables: definitions and basic properties. • Tail sigma-field and Kolmogorov zero–one law — statement, proof sketch, and examples. • Modes of convergence: almost sure (a.s.), in probability, in distribution (weak), and in rth mean (Lr). • Interrelationships: implications diagram, Slutsky's theorem, and counterexamples for non-implications. • Weak Law of Large Numbers: Chebyshev's version and Khintchine's version; conditions and applications. • Kolmogorov's inequality and Strong Law of Large Numbers (Kolmogorov's SLLN for i.i.d.; Marcinkiewicz–Zygmund statement). • Central Limit Theorem: Lindeberg–Lévy CLT — statement, proof via characteristic functions, and statistical applications. • Liapunov's theorem: Liapunov condition and CLT for independent non-identically distributed sequences. • Lindeberg–Feller theorem: Lindeberg condition, statement, and necessity (Feller's theorem). • Applications: consistency and asymptotic normality of sample mean; Delta method and its applications in inference.
Course Code	STP-1002	

Course Title	Practical in Probability Theory

Course Practical Content

1.	Verifying Probability Axioms and Rules
2.	Simulation and Analysis of Discrete Distributions
3.	Simulation and Analysis of Continuous Distributions
4.	Numerical Verification of Probability Inequalities
5.	Characteristic Functions
6.	Decomposition of Distribution Functions
7.	Stochastic Independence and Borel–Cantelli Lemma
8.	Conditional Expectation and Tower Property
9.	Modes of Convergence
10.	Weak Law of Large Numbers
11.	Strong Law of Large Numbers
12.	Central Limit Theorem
13.	Liapunov Condition and CLT for Non-Identical Variables

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓						
CO2	✓	✓						
CO3	✓	✓			✓			
CO4	✓	✓						✓
CO5			✓			✓		
CO6				✓	✓	✓		
CO7	✓				✓			✓
CO8							✓	✓

Reference Books

1.	Athreya, K. B., & Lahiri, S. N. (2006). Measure Theory and Probability Theory. New York: Springer. ISBN: 978-0387329031.
2.	Billingsley, P. (2012). Probability and Measure (4th ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-0470521939.
3.	Chung, K. L. (2001). A Course in Probability Theory (3rd ed.). San Diego: Academic Press. ISBN: 978-0121741518.
4.	Feller, W. (1968). An Introduction to Probability Theory and Its Applications (Vols. 1 & 2, 3rd ed.). New York: John Wiley & Sons. ISBN: 978-8126518050.
5.	Rohatgi, V. K., & Saleh, A. K. M. E. (2015). An Introduction to Probability and Statistics (3rd ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1118799680.
6.	Casella, G., & Berger, R. L. (2002). Statistical Inference (2nd ed.). Pacific Grove, California: Duxbury Press. ISBN: 978-0534243128.
7.	Durrett, R. (2019). Probability: Theory and Examples (5th ed.). Cambridge: Cambridge University Press. ISBN: 978-1108473682.
8.	Gut, A. (2013). Probability: A Graduate Course (2nd ed.). New York: Springer. ISBN: 978-1461447061.
9.	Resnick, S. I. (2014). A Probability Path. Boston: Birkhäuser. ISBN: 978-0817639242.
10.	Ross, S. M. (2014). A First Course in Probability (9th ed.). Boston: Pearson Education. ISBN: 978-0321794772.

11.	Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). New York: McGraw-Hill. ISBN: 978-0070431744.
12.	Hogg, R. V., McKean, J. W., & Craig, A. T. (2018). Introduction to Mathematical Statistics (8th ed.). Boston: Pearson Education. ISBN: 978-0134686998.
13.	Shiryaev, A. N. (2016). Probability (2nd ed.). New York: Springer. ISBN: 978-1493932386.
	Online Resources • NPTEL: Probability Theory and Applications (IIT level) — nptel.ac.in. • SWAYAM MOOCs: Probability and Statistics — swayam.gov.in • MIT OpenCourseWare — Probability and Random Variables 18.440 — ocw.mit.edu • JAMOVI Official Learning Resources — jamovi.or • Microsoft Excel Statistical Functions Documentation — support.microsoft.com o Coursera / edX Probability Courses by top universities JAMOVI Official Learning Resources (jamovi.org)

Teaching Methodology	Classwork, discussion, self-study through SWAYAM/NPTEL, Excel and JAMOVI lab sessions, seminars, assignments, and research-oriented exercises.
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

Major – 3
M. Sc. (Statistics) Semester I
Course: ST-1003 Linear Algebra

Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-1003					
Course Level	400-499					
Course Title	Linear Algebra					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the concepts of vector spaces, subspaces, basis, dimension and linear transformations.
CO-02:	Apply the concepts of linear dependence, independence and orthogonalization in solving mathematical and statistical problems.
CO-03:	Analyze different classes of matrices and their algebraic properties.
CO-04:	Compute rank, generalized inverse and Moore-Penrose inverse of matrices and apply them in statistical computations.
CO-05:	Reduce and classify quadratic forms and determine their index and signature.
CO-06:	Determine eigenvalues, eigenvectors and multiplicities of matrices and interpret their properties.
CO-07:	Apply matrix algebra and eigenvalue techniques in multivariate statistics, linear models and data analysis.
CO-08:	Utilize computational tools for matrix operations and numerical solutions of statistical problems.
CO-09:	Develop analytical and problem-solving skills required for advanced statistical theory and research.

Course Content

Unit-1	**Vector Spaces and Matrix Algebra** • Fields and Vector Spaces • Subspaces • Linear Dependence and Independence • Basis and Dimension of a Vector Space • Finite Dimensional Vector Spaces • Completion Theorem • Inner Product Spaces • Gram-Schmidt Orthogonalization Process • Orthogonal Basis and Orthonormal Basis • Symmetric, Skew-Symmetric, Hermitian and Skew-Hermitian Matrices • Orthogonal, Unitary and Normal Matrices

		• Laplace Expansion Method • Matrix Polynomials • Rank of a Matrix and Properties of Rank • Idempotent Matrices • Generalized Inverse and Moore-Penrose Generalized Inverse
	Unit-2	**Quadratic Forms and Characteristic Roots** • Real Quadratic Forms • Reduction and Classification of Quadratic Forms • Index and Signature of Quadratic Forms • Properties and Applications of Quadratic Forms • Characteristic Roots (Eigenvalues) and Characteristic Vectors (Eigenvectors) • Algebraic and Geometric Multiplicity • Properties of Characteristic Roots and Vectors of: • Symmetric Matrices • Hermitian Matrices • Skew-Hermitian Matrices • Orthogonal Matrices • Unitary Matrices • Normal Matrices • Diagonalization of Matrices • Applications of Eigenvalues and Eigenvectors in Statistics

Course Code	Practical in Linear Algebra
Course Title	STP-1003
Course Practical Content	

1.	Verification of Linear Dependence and Independence of Vectors
2.	Determination of Basis and Dimension of a Vector Space
3.	Computation of Inner Products and Norms of Vectors
4.	Gram-Schmidt Orthogonalization Process.
5.	Construction of Orthogonal and Orthonormal Bases
6.	Identification and Verification of Symmetric and Skew-Symmetric Matrices.
7.	Determination of Rank of a Matrix
8.	Verification of Properties of Rank
9.	Computation of Determinants using Laplace Expansion
10.	Matrix Polynomial Calculations
11.	Identification and Verification of Idempotent Matrices
12.	Computation of Generalized Inverse of a Matrix
13.	Computation of Moore-Penrose Generalized Inverse
14.	Reduction of Quadratic Forms to Canonical Form
15.	Determination of Index and Signature of Quadratic Forms
16.	Computation of Eigenvalues and Eigenvectors
17.	Verification of Algebraic and Geometric Multiplicity
18.	Diagonalization of Matrices using Eigenvalues and Eigenvectors

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓						✓	✓
CO2	✓	✓	✓				✓	✓
CO3	✓	✓	✓		✓		✓	✓
CO4	✓	✓	✓		✓		✓	✓
CO5	✓	✓	✓		✓		✓	✓
CO6	✓	✓	✓		✓		✓	✓
CO7	✓	✓	✓	✓	✓	✓	✓	✓
CO8		✓	✓	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books	1. Graybill, F. A. (1983): Matrices with Applications in Statistics, Wadsworth International Group, ISBN: 9780534980382. 2. Khuri, A. I. & Searle, S. R. (2017): Matrix Algebra Useful for Statistics, Wiley, ISBN: 9781118935163. 3. Ramachandra Rao, A. & Bhimasankaram, P. (2000): Linear Algebra, Hindustan Book Agency, ISBN: 9789386279019. 4. Bellman, R. (1997): Introduction to Matrix Analysis, Society for Industrial and Applied Mathematics (SIAM), ISBN: 9780898713992. 5. Biswas, S. (2012): Textbook of Matrix Algebra, PHI Learning, ISBN: 9788120346239. 6. Lipschutz, S. (1997): Schaum's Outline of Theory and Problems of Beginning Linear Algebra, McGraw-Hill, ISBN: 9780070380370. 7. Halmos, P. R. (2017): Finite-Dimensional Vector Spaces, Dover Publications, ISBN: 9780486822266. 8. Hoffman, K. & Kunze, R. (1971): Linear Algebra, 2nd Edition, Prentice Hall, ISBN: 9780135367971. 9. Shafarevich, I. R. & Remizov, A. O. (2012): Linear Algebra and Geometry, Springer, ISBN: 9783642309946. 10. Mitra, S. K. & Rao, C. R. (1971): Generalized Inverse of Matrices and Its Applications, Wiley, ISBN: 9780471708216. 11. Rao, C. R. (2009): Linear Statistical Inference and Its Applications, Wiley, ISBN: 9780470402726. 12. Gentle, J. E. (2017): Matrix Algebra: Theory, Computations and Applications in Statistics, Springer, ISBN: 9783319648897. 13. Abadir, K. M. & Magnus, J. R. (2005): Matrix Algebra, Cambridge University Press, ISBN: 9780521828925. 14. Harville, D. A. (2008): Matrix Algebra From a Statistician's Perspective, Springer, ISBN: 9780387784267. 15. Petersen, K. B. & Pedersen, M. S. (2012): The Matrix Cookbook, Technical University of Denmark.
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

Major-4
M. Sc. (Statistics) Semester I
Course: ST-1004 Indian Statistical Knowledge System

Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Major course on BKS (Subject Specific)					
Course Subtype	Nil					
Subject Type	Discipline Specific Course					
Course Code	ST-1004					
Course Level	500-599					
Course Title	Indian Statistical Knowledge System					
Credit	Theory:	4	Practical:	0	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Explain the historical evolution and philosophical foundations of the Indian Statistical Knowledge System (ISKS), including the contributions of ancient Indian civilizations, Sankhya Darshan, Nyaya, and Vedic traditions to statistical thinking.
CO-02:	Analyze the statistical and administrative practices of ancient India, including census systems, revenue administration, population enumeration, record keeping, and numerical developments as described in Arthashastra and related sources.
CO-03:	Examine the contributions of ancient and classical Indian scholars to probability, combinatorics, inference, arithmetic, and mathematical statistics, with reference to Pingala, Aryabhata, Brahmagupta, Bhaskara II, and Jain mathematical traditions.
CO-04:	Evaluate the evolution of statistical systems in India from the medieval period to modern times, including the statistical administration of the Delhi Sultanate, Mughal Empire, British India, and post-independence institutions.
CO-05:	Assess the relevance and application of Indian statistical knowledge in contemporary statistics, data science, artificial intelligence, and evidence-based decision-making.

Course Content

Unit-1	**Foundations of Indian Statistical Knowledge System** Introduction to Indian Statistical Knowledge System (ISKS), Concept of Statistics in Ancient India, Evolution of Quantitative Thinking in Indian Civilization, Sankhya Darshan and Enumeration, Ganana, Samkhya, Nyaya and Arthashastra as Foundations of Statistical Thought, Statistical Knowledge in the Indus Valley Civilization : (i) Standardized Weights (ii) Measures Town Planning and Urban Statistics, Vedic Period and Shulba Sutras: (i) Baudhayana (ii) Apastamba (iii) Manava (iv) Katyayana, Mathematical Foundations of Statistical Thinking

	Unit-2	**Statistical Administration and Numerical Systems in Ancient India** Mauryan Administration and Statistical Governance, Kautilya's Arthashastra: (i) Census System (ii) Revenue Statistics (iii) Agricultural Statistics (iv) Economic Administration, Administrative Record Keeping in Ancient India, Census, Vital Statistics and Population Enumeration, Development of Brahmi Numerals, Evolution of Hindu-Arabic Numeral System, Pāṭīgaṇita (Ancient Arithmetic), Role of Numerical Systems in Statistical Development
	Unit-3	**Probability, Inference and Classical Mathematical Contributions** Probability and Combinatorics in Ancient India, Pingala's Chhandasastra: (i) Binary Representation (ii) Guru-Laghu System, Meru-Prastara and Pascal's Triangle, Jain Mathematics and Vikalpa-Ganita, Bhagavati Sutra and Combinatorial Analysis, Nyaya Philosophy and Statistical Inference, Vatsyayana's Concept of Inference, Classical Age (Gupta Period) - Contributions of : (i) Aryabhata (ii) Brahmagupta (iii) Bhaskara II (iv) Lilavati and Statistical Concepts (Average, Combinations, Progressions, Approximation Methods)
	Unit-4	**Evolution of Modern Statistics in India** Statistical Administration during the Delhi Sultanate, Mughal Statistical System, Ain-i-Akbari as a Statistical Document : (i) Revenue Statistics (ii) Land Survey (iii) Administrative Statistics, Statistical Developments during British India : (i) Early Surveys (ii) Census Operations (iii) Institutionalization of Statistics, Emergence of Modern Statistics in India (Contributions of P. C. Mahalanobis, C. R. Rao, R. C. Bose, S. N. Roy), Indian Statistical Institute (ISI), National Sample Survey (NSS), Central Statistical Organization (CSO), Ministry of Statistics and Programme Implementation (MoSPI), Indian Statistical Knowledge System and Modern Data Science, ISKS in the Era of Artificial Intelligence and Big Data.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓			✓		✓	✓	✓
CO2	✓		✓	✓		✓		✓
CO3	✓		✓	✓				✓
CO4	✓		✓	✓		✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books

1. Abul Fazl. (1907). The Ain-i-Akbari (H. Blochmann & H. S. Jarrett, Trans.). Asiatic Society. (Original work published c. 1590)
2. Aryabhata. (1976). Aryabhatiya of Aryabhata (K. S. Shukla & K. V. Sarma, Trans.). Indian National Science Academy.
3. Baudhayana. (1932). Baudhayana Sulba Sutra (G. Thibaut, Trans.). Oriental Books Reprint Corporation
4. Bhaskara II. (1973). Lilavati (H. T. Colebrooke, Trans.). Motilal Banarsidass. (Original work published 1817)
5. Datta, B., & Singh, A. N. (1962). History of Hindu mathematics (Vols. 1–2). Asia Publishing House.
6. Gautama. (1990). Nyaya Sutras (M. Gangopadhyaya, Trans.). Indian Studies Press.
7. Goon, A. M. (1984). *History of statistics and statistical thinking in India*. Indian Statistical Institute
8. Joseph, G. G. (2011). The crest of the peacock: Non-European roots of mathematics (3rd ed.). Princeton University Press.

	9. Kautilya. (1915). Arthashastra (R. Shamasastry, Trans.). Mysore Government Oriental Library. 10. Mahalanobis, P. C. (1933). Some observations on the process of statistical enquiry in ancient India. Sankhya, 1(1), 1–12. 11. Mahalanobis, P. C. (1961). Collected papers of P. C. Mahalanobis. Pergamon Press 12. Mahalanobis, P. C. (1961). *The history of statistics in India*. Indian Statistical Institute 13. Mahadevan, B., Bhat, V. R., & Pavana, N. (2022). Introduction to Indian knowledge system: Concepts and applications. PHI Learning. 14. Pingala. (1938). Chhandasastra (M. R. Kale, Trans.). Motilal Banarsidass 15. Plofker, K. (2009). Mathematics in India. Princeton University Press. 16. Rao, C. R. (1989). *Statistics and truth: Putting chance to work* (2nd ed.). Wiley Eastern 17. Rao, C. R., & Sinha, B. K. (1996). Statistics in India. Wiley Eastern. 18. Singh, A. N. (1936). Mathematics of the Jains. Benares Mathematical Society. 19. Vatsyayana. (1990). Nyaya Bhashya (G. Jha, Trans.). Motilal Banarsidass.
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2603083101055001]
[Subject code for Practical-2603083101055002]

Multidisciplinary
M. Sc. (Statistics) Semester I
Course: ST-1005 Data Base Management System

Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Multidisciplinary					
Course Subtype	Employability					
Subject Type	Intra-Disciplinary					
Course Code	ST-1005					
Course Level	500-599					
Course Title	Data Base Management System					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the concepts, architecture and components of Database Management Systems.
CO-02:	Differentiate between various database models and evaluate their applications.
CO-03:	Design Entity Relationship (ER) models and relational database schemas for real-world problems.
CO-04:	Apply database constraints, keys and normalization concepts in database design.
CO-05:	Create, manipulate and manage databases using SQL commands.
CO-06:	Develop PL/SQL programs using procedures, functions, cursors and triggers.
CO-07:	Design and implement databases for statistical, research and business applications.
CO-08:	Utilize database tools for efficient storage, retrieval and management of large datasets.
CO-09:	Apply database management techniques in analytics, research, governance and decision-making environments.

Course Content

Unit-1	**Database Concepts and Relational Database Design** • Introduction to Database Management Systems (DBMS) • Advantages of DBMS over File Processing Systems • Database Languages: DDL, DML, DCL and TCL • Database Structure and Architecture • Levels of Abstraction in DBMS • Views of Data • Role of Database Users and Database Administrators • Data Models: Hierarchical, Network, Relational and Object-Oriented Models • Relational Database Management System (RDBMS) • Entity Relationship (ER) Model • ER Diagrams and Notations

	• Mapping Constraints • Primary Keys and Foreign Keys • Structural Constraints • Enhanced Entity Relationship (EER) Model
Unit-2	**SQL Programming and PL/SQL Applications** • Introduction to SQL • Data Definition Language (DDL) Commands • Data Manipulation Language (DML) Commands • Data Control Language (DCL) Commands • Transaction Control Language (TCL) Commands • Data Query and Retrieval Techniques • Introduction to PL/SQL • Stored Procedures • Functions • Cursors • Triggers • Applications of PL/SQL in Database Management • Database Design and Implementation for Statistical Data

Course Code	**STP-1005**
Course Title	**Practical in Data Base Management System**
Course Practical Content	

1.	Creation of Database and Tables using DDL Commands.
2.	Implementation of Primary Key and Foreign Key Constraints.
3.	Design of ER Diagram for a Statistical Survey Database.
4.	Conversion of ER Model into Relational Schema.
5.	Data Insertion, Updating and Deletion using DML Commands.
6.	Retrieval of Data using SELECT Queries.
7.	Use of Aggregate Functions (COUNT, SUM, AVG, MIN, MAX).
8.	Sorting and Filtering Records using ORDER BY and WHERE Clauses.
9.	Joining Multiple Tables using INNER JOIN, LEFT JOIN and RIGHT JOIN.
10.	Grouping Data using GROUP BY and HAVING Clauses.
11.	Implementation of Nested Queries and Subqueries.
12.	Creation and Use of Views.
13.	Transaction Processing using TCL Commands (COMMIT, ROLLBACK, SAVEPOINT).
14.	User Management and Permissions using DCL Commands.
15.	Creation of Stored Procedures.
16.	Development of User Defined Functions.
17.	Cursor Handling in PL/SQL. `
18.	Creation and Execution of Database Triggers.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓			✓			✓	✓
CO2	✓	✓	✓	✓			✓	✓
CO3	✓	✓	✓	✓	✓		✓	✓
CO4	✓	✓	✓	✓	✓		✓	✓
CO5		✓	✓	✓	✓	✓	✓	✓
CO6		✓	✓	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓	✓	✓	✓
CO8		✓	✓	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books	

1.	Date, C. J. (1999): An Introduction to Database Systems, 7th Edition, Pearson Education, ISBN: 9780201385908.
2.	Korth, H. F., Silberschatz, A. & Sudarshan, S. (2010): Database System Concepts, 6th Edition, McGraw-Hill Education, ISBN: 9780073523323.
3.	Ullman, J. D. (1994): Principles of Database Systems, 3rd Edition, Galgotia Publications, ISBN: 9788175156450.
4.	Desai, B. C. (2010): An Introduction to Database Systems, Revised Edition, Galgotia Publications, ISBN: 9788175156173.
5.	Elmasri, R. & Navathe, S. B. (2017): Fundamentals of Database Systems, 7th Edition, Pearson Education, ISBN: 9789332582705.
6.	Prakash, N. (1991): Introduction to Database Management, Tata McGraw-Hill, ISBN: 9780074602942.
7.	Feuerstein, S. & Pribyl, B. (2005): Oracle PL/SQL Programming, O'Reilly Media, ISBN: 9780596009779.
8.	Ramakrishnan, R. & Gehrke, J. (2003): Database Management Systems, 3rd Edition, McGraw-Hill, ISBN: 9780072465631.
9.	Garcia-Molina, H., Ullman, J. D. & Widom, J. (2008): Database Systems: The Complete Book, 2nd Edition, Pearson, ISBN: 9788131724743.
10.	Coronel, C. & Morris, S. (2019): Database Systems: Design, Implementation and Management, Cengage Learning, ISBN: 9781337627900.
11.	Silberschatz, A., Korth, H. F. & Sudarshan, S. (2020): Database System Concepts, 7th Edition, McGraw-Hill (eBook available).
12.	Connolly, T. & Begg, C. (2015): Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, ISBN: 9781292061184.
13.	Oppel, A. J. (2010): Databases: A Beginner's Guide, McGraw-Hill, ISBN: 9780071608466.
14.	Beaulieu, A. (2020): Learning SQL, 3rd Edition, O'Reilly Media, ISBN: 9781492057611.
15.	Viescas, J. L., Hernandez, M. J. & Viescas, D. (2018): SQL Queries for Mere Mortals, Addison-Wesley, ISBN: 9780134858333.
16.	Kleppmann, M. (2017): Designing Data-Intensive Applications, O'Reilly Media, ISBN: 9781449373320.

Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Internal Assessment: 25 Marks (TH) External Assessment: 25 Marks (TH)

Skill Enhancement Course
M. Sc. (Statistics) Semester I
Course: ST-1006 Statistical Computing with Excel & JAMOVI

Program Name	M. Sc. (Statistics)					
Semester	I					
NCrF Credit Level	6					
Course Type	Skill Enhancement Course					
Course Subtype	Skill Development & Employability					
Subject Type	Emerging Technology					
Course Code	ST-1006					
Course Level	500-599					
Course Title	Statistical Computing with Excel & JAMOVI					
Credit	Theory:		Practical:		Total:	2
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Prepare professional documents, reports and presentations using MS-Office tools.
CO-02:	Organize, manage and analyze statistical data using MS-Excel.
CO-03:	Create tables, charts and graphical representations for data interpretation.
CO-04:	Apply basic statistical techniques such as descriptive statistics, correlation and regression using JAMOVI.
CO-05:	Understand internet applications, communication tools and basic web technologies.
CO-06:	Develop computational and presentation skills useful for statistical analysis, research and professional applications.

Course Content

Unit-1	**Statistical Computing using MS-Office Tools** • Introduction to Windows and Office Applications • Typing, Editing, Proofing and Reviewing Documents in MS-Word • Formatting Text, Paragraphs, Tables and Graphics • Mail Merge and Document Preparation • Preparation of PowerPoint Presentations • Inserting Elements, Animation and Preparing Slide Shows • Working and Editing in Excel Worksheets • Creating Formats, Links and Charts (Graphs) • Data Management, Data Analysis and Printing in Excel • Importing, Sharing and Organizing Data
Unit-2	**Statistical Analysis using JAMOVI and Internet Applications** • Introduction to JAMOVI • Data Management and Functions in JAMOVI • Descriptive Statistics • Tabulation and Graphical Representation of Data • Measures of Central Tendency and Dispersion • Correlation and Linear Regression Analysis • Introduction to Internet and Internet Protocols (HTTP, FTP, TCP/IP)

	• Internet Utilities: E-mail, Chat and Searching • Web Browsers and Web Servers • Introduction to HTML and Basic HTML Tags

List of Exercise:

1. Preparation and Formatting of Statistical Reports using MS-Word
2. Creating Professional Presentations using MS-PowerPoint
3. Data Entry, Editing and Worksheet Management in MS-Excel
4. Data Visualization and Chart Preparation using Excel
5. Statistical Functions and Data Analysis in Excel
6. Data Management and Import/Export Operations in Excel
7. Descriptive Statistical Analysis using JAMOVI
8. Preparation of Statistical Graphs and Tables using JAMOVI
9. Measures of Central Tendency and Dispersion using JAMOVI
10. Correlation and Linear Regression Analysis using JAMOVI
11. Internet Applications, E-mail and Online Information Search
12. Introduction to Web Browsers, Web Servers and Basic HTML Tags

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1		✓					✓	✓
CO2	✓	✓	✓		✓	✓		✓
CO3	✓	✓		✓	✓		✓	
CO4	✓	✓	✓	✓	✓	✓		✓
CO5		✓				✓	✓	✓
CO6		✓	✓	✓	✓	✓	✓	✓

Reference Books

1.	Dienes, S. (1993): Word 6 for Windows Quick & Easy Reference, BPB Publications, ISBN: 9788170292975.
2.	Layman, E. & Hart, J. (1995): WordPerfect 6.0 for Windows: Book and Quick Reference, Prentice Hall, ISBN: 9780130346537.
3.	Mansfield, R. (1994): Mastering Word 6 for Windows, BPB Publications, ISBN: 9788170292982.
4.	Townsend, C. (1994): Mastering Excel 4 for Windows, BPB Publications, ISBN: 9788170292302.
5.	Navarro, D. J. & Foxcroft, D. R. (2018): Learning Statistics with JAMOVI: A Tutorial for Psychology Students and Other Beginners, ISBN: 9781735189901.
6.	Rafi, J. (2020): The JAMOVI Quickstart Guide, ISBN: 9781690762867.
7.	Chaudhari, S. & Raykundaliya, D. (2025): Statistical Analysis Made Simple Using Microsoft Excel, ISBN:9789390256358
8.	Steve Holzner, HTML Black Book, The Programmer's Complete HTML Reference Book, Paraglyph, Incorporated, ISBN-9781932111309
9.	H. M. Deitel; P. J. Deitel; A. B. Goldberg, Internet & World Wide Web: How to Program, Pearson India, 2012, ISBN- 978-9332519206
10.	Kamden K. Strunk and Mwarumba Mwavita, Design and Analysis in Educational Research Using jamovi: ANOVA Designs, Routledge, ISBN- 978-0367723064
11.	Danielle Navarro and David Foxcroft, Learning Statistics with Jamovi: A Tutorial for Beginners in Statistical Analysis, Open Book Publishers, ISBN-978-1800649378
12.	Paul McFedries, Microsoft Excel Formulas and Functions (Office 2021 and Microsoft 365), Pearson Education, ISBN- 978-8119847372

Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Internal Assessment: 25 Marks External Assessment: 25 Marks **Note: Exam of Skill Enhancement course be taken on computers**

AFTER U. G. (3 Years) – P. G. – General –M. Sc. (Statistics) – Only Course Work
[1] – A TWO-YEAR PG WITH COURSE WORK ONLY – SEMESTER-(22 Credits) – SEM- II

Course Category	Course Code	Course Title	Mark sheet Title in English	Level of Course	Teaching Hours/Week		Exam Duration $		Credit		Internal Marks		External Marks		Total Marks	
					TH	PR*	TH	PR*	TH	PR*	TH	PR*	TH	PR*	TH	PR*
Major-1	ST-2001	Univariate Distributions	Univariate Distributions	400-499	2				2		25		25		50	
Major-1	STP-2001	Univariate Distributions	Univariate Distributions	400-499		4				2		25		25		50
Major-2	ST-2002	Estimation Theory	Estimation Theory	400-499	2				2		25		25		50	
Major-2	STP-2002	Estimation Theory	Estimation Theory	400-499		4				2		25		25		50
Major-3	ST-2003	Multivariate Analysis	Multivariate Analysis	400-499	2				2		25		25		50	
Major-3	STP-2003	Multivariate Analysis	Multivariate Analysis	400-499		4				2		25		25		50
Major-4 **OR** Internship #	ST-20041	Linear Models	Linear Models	500-599	2				2		25		25		50	
	STP-20041	Linear Models	Linear Models	500-599		4				2		25		25		50
	ST-20042	Internship	Internship	500-599	-	-	-	-	4		50		50		100	
Major-5 (THEORY)	ST-20051 **OR** ST-20052 **OR** ST-20053	Bayesian Inference **OR** Categorical Data Analysis **OR** Data Mining	Bayesian Inference **OR** Categorical Data Analysis **OR** Data Mining	500-599	2				2		25		25		50	
Major-5 (PRACTICAL)	STP-20051 **OR** STP-20052 **OR** STP-20053	Bayesian Inference **OR** Categorical Data Analysis **OR** Data Mining	Bayesian Inference **OR** Categorical Data Analysis **OR** Data Mining	500-599		4				2		25		25		50
		MOOC Course	MOOC Course	500-599	-	-	-	-	4		-	-	-	-	-	-
Skill Enhancement Course	ST-2006	Computer Programming Language-C	Computer Programming Language-C	500-599	2				2		25		25		50	
				Total Hours For Students:	= 32											
				Total Hours For the Department:	= 12hrs. Fixed for theory + 22 hrs. /batch of practical & Skill Enhancement											

NOTE: * (1) Maximum Batch size for practical be 10-15 students as per NEP 2020 guidelines
(2) For practical examinations maximum 10 students will be allotted to one examiner per batch per session per course
(3) Exam of Skill Enhancement course be taken on computers
(4) # Evaluation of the internship will be done as per the prevailing university norms.
(5) $ Exam duration will be as per university circular.

[Subject code for Theory-2703083102011001]

[Subject code for Practical-2703083102011002]

Major – 1
M. Sc. (Statistics) Semester II
Course: ST-2001 Univariate Distributions

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-2001					
Course Level	400-499					
Course Title	Univariate Distributions					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the properties and applications of important continuous probability distributions such as Laplace, Lognormal, Cauchy, Weibull and Logistic distributions.
CO-02:	Apply truncated probability distributions in situations involving restricted or incomplete observations.
CO-03:	Analyse compound and contagious distributions used in modelling count and risk-related phenomena.
CO-04:	Understand and apply power series distributions and their statistical properties.
CO-05:	Interpret and apply non-central probability distributions in advanced statistical inference problems.
CO-06:	Analyse order statistics and range distributions arising from random samples.
CO-07:	Utilize computational tools to evaluate probabilities, distribution functions and statistical measures associated with univariate distributions.
CO-08:	Apply distribution theory to real-life problems in reliability, quality control, actuarial science and data analysis.

Course Content

Unit-1	**Continuous and Truncated Distributions** • Review of Laplace, Lognormal and Cauchy Distributions • Weibull Distribution: Properties and Applications • Logistic Distribution: Properties and Applications • Concept of Truncated Distributions • Truncated Binomial Distribution • Truncated Poisson Distribution • Truncated Normal Distribution • Applications of Truncated Distributions

	Unit-2	**Compound, Non-Central and Order Statistics** • Univariate Compound Distributions • Contagious Distributions: Neyman Type-A Distribution • Poisson-Binomial Distribution • Poisson-Negative Binomial Distribution • Univariate Power Series Distributions • Non-central t, F and Chi-square Distributions • Order Statistics: Distribution and Properties • Distribution and Properties of Range • Applications of Order Statistics in Statistical Inference

Course Code	STP-2001
Course Title	Practical in Univariate Distributions
Course Practical Content	

1.	Computation and graphical representation of Laplace, Lognormal and Cauchy Distribution.
2.	Estimation of probabilities and percentiles for Weibull Distribution.
3.	Estimation of probabilities and percentiles for Logistic Distribution.
4.	Construction and analysis of Truncated Binomial Distribution.
5.	Construction and analysis of Truncated Poisson Distribution.
6.	Construction and analysis of Truncated Normal Distribution.
7.	Computation of probabilities for Poisson-Binomial Distribution.
8.	Fitting of Neyman Type-A Distribution.
9.	Computation of probabilities and moments for Power Series Distributions.
10.	Evaluation of Non-central t, Non-central F Distribution and Non-central Chi-square Distribution probabilities
11.	Computation of Order Statistics from random samples.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓			✓				✓
CO2	✓	✓	✓	✓				✓
CO3	✓	✓	✓	✓	✓			✓
CO4	✓	✓	✓		✓			✓
CO5	✓	✓	✓	✓	✓			✓
CO6	✓	✓	✓	✓			✓	✓
CO7		✓	✓		✓	✓	✓	✓
CO8	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books

1.	Johnson, N. L. & Kotz, S. (1970): Distributions in Statistics, John Wiley & Sons, ISBN: 9780471715812.
2.	Rohatgi, V. K. (1984): Statistical Inference, John Wiley & Sons, ISBN: 9780471360914.
3.	Rohatgi, V. K. (1976): An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, ISBN: 9780471272144.
4.	Patel, J. K., Kapadia, C. H. & Owen, D. B. (1996): Handbook of Statistical Distributions, Marcel Dekker, ISBN: 9780824790469.
5.	Mood, A. M., Graybill, F. A. & Boes, D. C. (1974): Introduction to the Theory of Statistics, McGraw-Hill, ISBN: 9780070380452.
6.	Rao, C. R. (1965): Linear Statistical Inference and Its Applications, Wiley, ISBN: 9780471754989.

7.	Arnold, B. C., Balakrishnan, N. & Nagaraja, H. N. (1992): A First Course in Order Statistics, John Wiley & Sons, ISBN: 9780470284439.
8.	Johnson, N. L., Kotz, S. & Balakrishnan, N. (2000): Discrete Univariate Distributions, 2nd Edition, John Wiley & Sons, ISBN: 9780471584953.
9.	Johnson, N. L., Kotz, S. & Balakrishnan, N. (2000): Continuous Univariate Distributions (Vol. 1), 2nd Edition, John Wiley & Sons, ISBN: 9780471584946.
10.	Evans, M., Hastings, N. & Peacock, B. (2000): Statistical Distributions, 3rd Edition, Wiley, ISBN: 9780471371248.
11.	Gupta, S. C. & Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand & Sons, ISBN: 9789351613312.
12.	Hogg, R. V., McKean, J. W. & Craig, A. T. (2019): Introduction to Mathematical Statistics, 8th Edition, Pearson Education, ISBN: 9780134686998.

Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2703083102022001]

[Subject code for Practical-2703083102022002]

Major – 2
M. Sc. (Statistics) Semester II
Course: ST-2002 Estimation Theory

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-2002					
Course Level	400-499					
Course Title	Estimation Theory					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the concepts of statistical estimation, estimators and desirable properties of estimators.
CO-02:	Evaluate estimators using unbiasedness, consistency, efficiency and Pitman's closeness criteria.
CO-03:	Identify and derive sufficient, minimal sufficient and complete sufficient statistics for statistical models.
CO-04:	Apply Rao-Blackwell and Lehmann-Scheffé theorems to obtain efficient estimators and UMVUEs.
CO-05:	Construct estimators using Maximum Likelihood, Method of Moments and other estimation techniques.
CO-06:	Derive and interpret lower bounds such as Cramér-Rao, Chapman-Robbins and Bhattacharya bounds.
CO-07:	Construct and interpret confidence intervals and confidence bounds for population parameters.
CO-08:	Apply estimation procedures to real-life statistical problems using computational tools and data analysis techniques.
CO-09:	Develop analytical and research skills required for advanced statistical inference and data-driven decision making.

Course Content

Unit-1	**Properties of Estimators** • Concept of Estimator and Estimate • Measures of Closeness of an Estimator: Pitman's Closeness Criterion • Unbiased and Biased Estimators • Consistent Estimators and Theorems on Consistency • Efficiency of Estimators • Best Linear Combination of Unbiased Estimators • Best Asymptotically Normal (BAN) Estimators • Sufficient Statistics • Neyman Factorization Theorem (Discrete Case)

		• Minimal Sufficient Statistics • Complete Sufficient Statistics
	Unit-2	**Theorem-Inequality, Methods of Estimation and Confidence Intervals** • Minimum Variance Unbiased Estimation (MVUE) • Cramér-Rao Lower Bound and Cramér-Rao Inequality • Chapman-Robbins Inequality • Bhattacharya Inequality • Rao-Blackwell Theorem • Lehmann-Scheffé Theorem • Uniformly Minimum Variance Unbiased Estimator (UMVUE) • One Parameter Exponential Family of Distributions • Maximum Likelihood Estimation (MLE) and Its Properties • Method of Moments • Method of Minimum Chi-square and Modified Minimum Chi-square • Method of Scoring • MLE for Grouped Data • Location and Scale Invariant Estimators • Confidence Intervals and Confidence Bounds • Large Sample Confidence Intervals • Confidence Intervals for Parameters of Elementary Distributions • Confidence Bounds of Fixed Length • Stein's Two-Stage Procedure

Course Code	STP-2002
Course Title	Practical in Estimation Theory
Course Practical Content	

1.	Computation of Point Estimates for Population Mean and Variance.
2.	Comparison of Biased and Unbiased Estimators
3.	Study of Consistency of Estimator
4.	Study of Efficiency of Estimators.
5.	Construction of Best Linear Unbiased Estimators.
6.	Identification of Sufficient Statistics for Standard Distributions.
7.	Estimation of Parameters using Method of Moments.
8.	Estimation of Parameters using Maximum Likelihood Method.
9.	Estimation of Parameters for Grouped Data.
10.	Computation of Fisher Information and Cramér-Rao Lower Bound.
11.	Verification of Rao-Blackwell Improvement of Estimators.
12.	Construction of UMVUE for Selected Distributions.
13.	Construction of Confidence Intervals for Population Mean and Population Variance
14.	Application of Stein's Two-Stage Procedure using Sample Data.
15.	Comparative Study of MLE and Method of Moments Estimators.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓						✓	✓
CO2	✓	✓	✓				✓	✓
CO3	✓	✓	✓				✓	✓
CO4	✓	✓	✓		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓			✓
CO6	✓	✓	✓	✓	✓		✓	✓

CO7	✓	✓	✓	✓	✓	✓	✓	✓
CO8		✓	✓	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books

1.	Mood, A. M., Graybill, F. A. & Boes, D. C. (2001): Introduction to the Theory of Statistics, McGraw-Hill, ISBN: 9780070445208.
2.	Goon, A. M., Gupta, M. K. & Dasgupta, B. (2000): An Outline of Statistical Theory, Vol. I & II, World Press, ISBN: 9788187567264.
3.	Rohatgi, V. K. (1976): An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, ISBN: 9780471731351.
4.	Mukhopadhyay, P. (2014): Mathematical Statistics, Books and Allied (P) Ltd., ISBN: 9788187134930.
5.	Rao, C. R. (2001): Linear Statistical Inference and Its Applications, 2nd Edition, Wiley, ISBN: 9780471218753.
6.	Casella, G. & Berger, R. L. (2024): Statistical Inference, 2nd Edition (Reprint), CRC Press, ISBN: 9781032597942.
7.	Mukhopadhyay, N. (2006): Introductory Statistical Inference, Chapman & Hall/CRC, ISBN: 9781574446135.
8.	Hogg, R. V., McKean, J. W. & Craig, A. T. (2019): Introduction to Mathematical Statistics, 8th Edition, Pearson, ISBN: 9780134686998.
9.	Lehmann, E. L. & Casella, G. (1998): Theory of Point Estimation, 2nd Edition, Springer, ISBN: 9780387985022.
10.	Kale, B. K. (1999): A First Course on Parametric Inference, Narosa Publishing House, ISBN: 9788173193958.
11.	Srivastava, M. K., Khan, A. H. & Srivastava, N. (2014): Statistical Inference: Theory of Estimation, Prentice Hall India, ISBN: 9788120349308.
12.	Mukhopadhyay, N. (2006): Introductory Statistical Inference, Chapman & Hall/CRC, ISBN: 9781574446135.

Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2703083102033001]
[Subject code for Practical-2703083102033002]

Major – 3
M. Sc. (Statistics) Semester II
Course: ST-2003 Multivariate Analysis

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-2003					
Course Level	400-499					
Course Title	Multivariate Analysis					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand multivariate probability distributions and their statistical properties.
CO-02:	Derive and apply marginal, conditional and sampling distributions associated with multivariate normal populations.
CO-03:	Analyse generalized variance and Wishart distributions in multivariate statistical inference.
CO-04:	Compute and interpret multiple and partial correlation coefficients and perform associated significance tests.
CO-05:	Apply Hotelling's T^2 statistic and MANOVA techniques for multivariate hypothesis testing.
CO-06:	Solve classification problems using Fisher's discriminant analysis and evaluate misclassification probabilities.
CO-07:	Apply dimension reduction techniques such as Principal Component Analysis, Factor Analysis and Canonical Correlation Analysis.
CO-08:	Utilize statistical software and computational tools for analysing multivariate datasets and interpreting results.
CO-09:	Apply multivariate statistical techniques to real-world problems in research, industry, healthcare, business analytics and public policy.

Course Content

Unit-1	**Multivariate Distributions and Correlation Analysis** • Multinomial Distribution: Marginal and Conditional Distributions, Characteristic Function • Multivariate Normal Distribution: Properties, Marginal and Conditional Distributions • Distribution of Linear Functions and Sample Mean Vector • Characteristic Function of Multivariate Normal Distribution • Generalized Variance and Distribution of Sample Generalized Variance • Wishart Distribution: Probability Density Function and Properties • All properties of Wishart Distribution

		• Characteristic Function of Wishart Distribution • Multiple Correlation Coefficient and Partial Correlation Coefficient • Null and Non-null Distribution of Sample Correlation Coefficient • Tests of Significance of Multiple and Partial Correlation Coefficients
	Unit-2	**Multivariate Inference and Dimension Reduction Techniques** • Hotelling's T^2 Statistic and its Null Distribution • Tests on Single Mean Vector • Tests for Two Independent Multivariate Normal Populations (Equal and Unequal Covariance Matrices) • Tests for Dependent Samples • Problem of Symmetry • Multivariate Analysis of Variance (MANOVA): One-Way Classification • Classification Problems and Fisher's Linear Discriminant Function • Probabilities of Misclassification • Classification with More Than Two Multivariate Normal Populations • Introduction to Factor Analysis and Applications • Principal Component Analysis (PCA): Concepts and Applications • Canonical Correlation Analysis: Concepts and Applications

Course Code	STP-2003
Course Title	Practical in Multivariate Analysis

Course Practical Content

1.	Computation of Point Estimates for Population Mean and Variance.
2.	Comparison of Biased and Unbiased Estimators
3.	Study of Consistency of Estimator
4.	Study of Efficiency of Estimators.
5.	Construction of Best Linear Unbiased Estimators.
6.	Identification of Sufficient Statistics for Standard Distributions.
7.	Estimation of Parameters using Method of Moments.
8.	Estimation of Parameters using Maximum Likelihood Method.
9.	Estimation of Parameters for Grouped Data.
10.	Computation of Fisher Information and Cramér-Rao Lower Bound.
11.	Verification of Rao-Blackwell Improvement of Estimators.
12.	Construction of UMVUE for Selected Distributions.
13.	Construction of Confidence Intervals for Population Mean and Population Variance
14.	Application of Stein's Two-Stage Procedure using Sample Data.
15.	Comparative Study of MLE and Method of Moments Estimators.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓						✓	✓
CO2	✓	✓	✓				✓	✓
CO3	✓	✓	✓		✓		✓	✓
CO4	✓	✓	✓	✓	✓		✓	✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓	✓	✓	✓
CO8		✓	✓	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books	1. Anderson, T. W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edition, Wiley-Inter science, ISBN: 9780471360919. 2. Johnson, R. A. & Wichern, D. W. (2008): Applied Multivariate Statistical Analysis, 6th Edition, Pearson Education, ISBN: 9788131722220. 3. Fienberg, S. E., Olkin, I. & Jobson, J. D. (1994): Applied Multivariate Data Analysis: Volume II, Springer, ISBN: 9780387978048. 4. Kshirsagar, A. M. (1972): Multivariate Analysis, Marcel Dekker, ISBN: 9780824713867. 5. Mardia, K. V., Kent, J. T. & Bibby, J. M. (1980): Multivariate Analysis, Academic Press, ISBN: 9780124712522. 6. Morrison, D. F. (2004): Multivariate Statistical Methods, 4th Edition, Thomson Brooks/Cole, ISBN: 9780534387785. 7. Marcoulides, G. A., Hershberger, S. L. (1997): Multivariate Statistical Methods: A First Course, Lawrence Erlbaum Associates, ISBN: 9780805825725. 8. Muirhead, R. J. (2005): Aspects of Multivariate Statistical Theory, Wiley, ISBN: 9780471769859. 9. Seber, G. A. F. (1984): Multivariate Observations, Wiley, ISBN: 9780471881049. 10. Srivastava, M. S. & Khatri, C. G. (1979): An Introduction to Multivariate Statistics, North-Holland, ISBN: 9780444003027. 11. Srivastava, M. S. (2002): Methods of Multivariate Statistics, Wiley, ISBN: 9780471223818. 12. Härdle, W. & Hlávka, Z. (2007): Multivariate Statistics: Exercises and Solutions, Springer, ISBN: 9780387707846. 13. Rencher, A. C. & Christensen, W. F. (2012): Methods of Multivariate Analysis, 3rd Edition, Wiley, ISBN: 9780470178966. 14. Izenman, A. J. (2013): Modern Multivariate Statistical Techniques, Springer, ISBN: 9780387781884. 15. Everitt, B. S. & Hothorn, T. (2011): An Introduction to Applied Multivariate Analysis with R, Springer, ISBN: 9781441996497.
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2703083102044001]
[Subject code for Practical-2703083102044002]

Major – 4 M. Sc. (Statistics) Semester II Course: ST-2004 Linear Models						
Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-2004					
Course Level	500-599					
Course Title	Linear Models					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Demonstrate understanding of General Linear Models, Gauss-Markov theory and least squares estimation.
CO-02:	Apply simple and multiple regression techniques for modelling real-life datasets.
CO-03:	Analyze generalized least squares estimators, restrictions and estimability concepts.
CO-04:	Apply generalized inverses, quadratic forms and Cochran's theorem in statistical inference.
CO-05:	Perform testing of general linear hypotheses and ANOVA models.
CO-06:	Utilize Excel (Data Analysis ToolPak), JAMOVI and C programming to perform regression analysis, ANOVA, diagnostics and linear model computations in alignment with NEP 2020 computational skill requirements.

Course Content

Unit-1	General Linear Models and Estimation Theory Statistical modelling; General Linear Model; Gauss-Markov set-up; Simple and Multiple Linear Regression; OLS estimation; normal equations; confidence intervals; t-tests; residual analysis; coefficient of determination; matrix formulation; hypothesis testing; prediction; multicollinearity; Generalized Least Squares; estimation of linear parametric functions; restricted least squares estimation; simultaneous estimation; error and estimation spaces; generalized inverse and applications.
Unit-2	Inference, Quadratic Forms and Applications Quadratic forms; canonical forms; distribution and independence of quadratic forms; Cochran's theorem; General Linear Hypotheses; testing linear hypotheses; likelihood ratio tests; estimation under null hypothesis; one-way and two-way ANOVA; regression diagnostics; leverage; Cook's distance; model validation; introduction to generalized linear models;

	applications in industry, business analytics, public health and environmental studies.
Course Code	STP-2004
Course Title	Practical in Linear Models
Course Practical Content	1. Exploratory Data Analysis using Excel: data entry, sorting, filtering, descriptive statistics (mean, variance, skewness, kurtosis) using Excel functions and Data Analysis ToolPak; frequency tables and histograms; cross-verification in JAMOVI 2. Simple Linear Regression using Excel Data Analysis ToolPak: scatter plot, regression output, interpretation of coefficients, R^2 and standard error; cross-verification using JAMOVI (Linear Regression module) 3. Residual Analysis: residual plots and normal probability plots using Excel (Data Analysis ToolPak regression output); Shapiro-Wilk normality test and Q-Q plot in JAMOVI; C program to compute residuals and their sum of squares 4. Multiple Linear Regression: OLS estimation using Excel Data Analysis ToolPak; C program to solve the normal equations $(X'X)\beta = X'y$ by Gaussian elimination for a three-predictor model; results cross-verified in JAMOVI 5. Testing Regression Coefficients: t-tests and overall F-test from Excel regression output; manual computation of t-statistics and critical values using Excel functions; cross-verification in JAMOVI; C program to compute the F-statistic from SS values 6. Confidence and Prediction Intervals: computation using Excel FORECAST.LINEAR, CONFIDENCE.T functions and manual formulas; graphical display using Excel charts; JAMOVI regression output for 95% CI on coefficients; C program to compute the standard error of prediction at a given point 7. ANOVA for Regression: partitioning SS(Total), SS(Regression) and SS(Residual) using Excel Data Analysis ToolPak regression output; manual construction of ANOVA table in Excel; C program to compute SS values and the F-statistic from input data 8. One-way ANOVA: Excel Data Analysis ToolPak (ANOVA: Single Factor); JAMOVI ANOVA module with descriptive statistics and effect size; C program to compute group means, SS(Between) and SS(Within) and the F-statistic from raw data 9. Two-way ANOVA: Excel Data Analysis ToolPak (ANOVA: Two-Factor With Replication and Without Replication); interaction plots in Excel; post-hoc Tukey HSD in JAMOVI; C program to compute row, column and interaction SS for a balanced two-way layout 10. General Linear Model and Generalized Least Squares: weighted least squares in Excel using LINEST with known weights; JAMOVI linear model with weighted estimation; C program to implement weighted least squares ($W = \mathrm{diag}(w_1, \ldots, w_n)$) for a two-predictor model 11. Regression Diagnostics: identification of outliers and leverage points using Excel (standardised residuals and hat values computed manually); Cook's distance computed in Excel; JAMOVI regression diagnostics panel; C

program to compute hat-matrix diagonal (leverage values) from the X matrix

12. Cochran's Theorem and Quadratic Forms: numerical verification of idempotency and rank conditions for projection matrices using Excel matrix functions (MMULT, MINVERSE, MDETERM); C program to compute and display the quadratic form x'Ax for user-supplied matrix A and vector x
13. Generalized Inverses: computation of a generalized inverse for rank-deficient matrices using Excel (via SVD approach with MINVERSE on full-rank sub-matrices); verification in JAMOVI for estimable functions; C program to verify the condition A·G·A = A for a given generalized inverse G.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓						✓
CO2	✓	✓	✓	✓	✓			✓
CO3	✓	✓		✓	✓	✓		✓
CO4	✓	✓			✓	✓		✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓
CO6		✓	✓	✓		✓	✓	✓

Reference Books

1.	Chatterjee, S., & Hadi, A. S. (2015). Regression Analysis by Example (5th ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1119122739.
2.	Goss-Sampson, M. A. (2022). Statistical Analysis in JAMOVI: A Guide for Students and Researchers.
3.	Graybill, F. A. (1976). An Introduction to Linear Statistical Models (Vol. 1). New York: McGraw-Hill. ISBN: 978-0070243002.
4.	Gujarati, D. N., & Porter, D. C. (2009). Basic Econometrics (5th ed.). New York: McGraw-Hill Education. ISBN: 978-0073375779.
5.	Kernighan, B. W., & Ritchie, D. M. (1988). The C Programming Language (2nd ed.). Englewood Cliffs, NJ: Prentice Hall. ISBN: 978-0131103627.
6.	Kshirsagar, A. M. (1972). A Course in Linear Models. New York: Marcel Dekker. ISBN: 978-0824712440.
7.	Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). Applied Linear Statistical Models (5th ed.). New York: McGraw-Hill/Irwin. ISBN: 978-0073108742.
8.	Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Introduction to Linear Regression Analysis (6th ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1119578727.
9.	Navarro, D. J., & Foxcroft, D. R. (2022). Learning Statistics with JAMOVI: A Tutorial for Psychology Students and Other Beginners.
10.	Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). Numerical Recipes in C: The Art of Scientific Computing (3rd ed.). Cambridge: Cambridge University Press. ISBN: 978-0521880688.
11.	Quirk, T. J., & Quirk, M. (2023). Excel 2019 for Statistics: A Guide to Solving Practical Statistics Problems (6th ed.). Cham: Springer. ISBN: 978-3031128462.
12.	Rao, C. R. (2002). Linear Statistical Inference and Its Applications (2nd ed.). New York: John Wiley & Sons. ISBN: 978-0471705840.
13.	Searle, S. R., & Gruber, M. H. J. (2017). Linear Models (2nd ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1119302605.

		14.	Weisberg, S. (2014). Applied Linear Regression (4th ed.). Hoboken, NJ: John Wiley & Sons. ISBN: 978-1118594858.
		Open Educational Resources (SWAYAM/NPTEL – aligned with UGC-NET & GSET)	
		15.	NPTEL. Linear Statistical Models. Indian Institute of Technology. Available at: nptel.ac.in
		16.	NPTEL. Regression Analysis. Indian Institute of Technology. Available at: nptel.ac.in
		17.	NPTEL. Linear Statistical Models. Indian Institute of Technology. Available at: nptel.ac.in
		18.	NPTEL / SWAYAM. Programming in C. Indian Institute of Technology. Available at: nptel.ac.in
		19.	JAMOVI Project. JAMOVI (Version 2.x) [Computer Software]. Available at: jamovi.org
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM/NPTEL (aligned with UGC-NET and GSET syllabi), Excel and JAMOVI based computational laboratory sessions, C programming exercises, Seminars, Assignments, and Mini Projects promoting research aptitude as per NEP 2020 PG guidelines.		
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks		

[Subject code for Theory-2703083102055001]

[Subject code for Practical-2703083102055002]

Major – 5 M. Sc. (Statistics) Semester II Course: ST-20051 Bayesian Inference						
Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-20051					
Course Level	500-599					
Course Title	Bayesian Inference					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Explain Bayes' theorem, subjective and objective priors, likelihood, posterior distributions and their properties (NET Unit I, IV; ISS Paper II).
CO-02:	Derive posterior distributions for standard conjugate Bayesian models and interpret sensitivity to prior specification (NET Unit IV; ISS Paper II).
CO-03:	Obtain Bayesian estimators under different loss functions and compare their properties with frequentist estimators (NET Unit IV; ISS Paper II; GSET).
CO-04:	Construct and interpret credible intervals and HPD intervals, and compare them with classical confidence intervals (NET Unit IV; ISS Paper II).
CO-05:	Perform Bayesian hypothesis testing using Bayes factors and posterior odds; relate to classical testing (NET Unit V; ISS Paper II).
CO-06:	Apply Bayesian methods to real datasets using Excel, JAMOVI and C language, and communicate findings through written reports (NEP 2020 skill outcome; ISS Paper III).

Course Content

Unit-1	**Foundations of Bayesian Inference** **Probability & Likelihood Review:** Conditional probability, total probability and Bayes' theorem — discrete and continuous forms, Likelihood function; connection between MLE and Bayesian approach, Sufficiency, ancillarity and the likelihood principle **Prior Distributions:** Subjective (informative) priors and objective (non-informative) priors, Jeffreys' prior and reference priors, Maximum entropy priors, Conjugate priors: definition, concept and practical advantages **Posterior Distribution:** Posterior $\propto$ likelihood $\times$ prior: derivation and interpretation, Posterior mean, variance, mode and median,

		Posterior predictive distribution, Beta-Binomial conjugate model, Gamma-Poisson conjugate model, Normal-Normal conjugate model (known and unknown variance), Dirichlet-Multinomial model Loss Functions & Bayes Estimators: Squared error loss (SEL): Bayes estimator = posterior mean, Absolute error loss (AEL): Bayes estimator = posterior median, 0-1 loss: Bayes estimator = posterior mode, LINEX (linear-exponential) loss: asymmetric loss and Bayes estimator, Posterior expected loss and Bayes risk **Decision Theory:** Admissibility of estimators; relationship between Bayes and admissible estimators, Minimax estimation and minimax principle, Comparison of Bayes estimators with MLE and UMVUE, Empirical Bayes estimation: parametric and non-parametric approaches **Interval Estimation:** Bayesian credible intervals: equal-tails credible interval, Highest Posterior Density (HPD) intervals: definition and construction, Predictive intervals, Comparison with classical confidence intervals, Sensitivity of posterior to prior hyperparameter choice
	Unit-2	**Bayesian Hypothesis Testing & Model Selection** **Bayesian Testing:** Prior probability and posterior probability of hypotheses, Prior odds and posterior odds, Bayes factor: definition, interpretation and computation, Bayes factor for simple vs. simple hypotheses, Bayes factor for simple vs. composite hypotheses, Point null hypothesis: posterior probability approach, Lindley's paradox: numerical illustration and interpretation, Comparison of Bayesian and classical (Neyman-Pearson) testing **Model Selection:** Posterior model probabilities, Bayesian Information Criterion (BIC): derivation and use, Deviance Information Criterion (DIC), Bayes factor as a model comparison tool **Predictive Checking:** Prior predictive distribution, Posterior predictive distribution and posterior predictive p-values
Course Code	STP-20051	
Course Title	Practical in Bayesian Inference	
Course Practical Content	1. Computation of conditional probabilities using Excel (tabular and formula methods) 2. Verification of Bayes' theorem for discrete models using Excel pivot tables 3. Verification of Bayes' theorem for continuous distributions: numerical integration in Excel 4. Plotting of prior, likelihood and posterior distributions for Beta-Binomial model in Excel 5. Gamma-Poisson conjugate model: posterior parameter computation and graphical display in Excel 6. Normal-Normal conjugate model (known variance): posterior mean and variance computation in Excel 7. Normal-Normal conjugate model (unknown variance): Normal-Inverse-Gamma posterior in Excel 8. Dirichlet-Multinomial model: posterior Dirichlet parameters and posterior mean computation in Excel 9. Computation of posterior mean, variance, mode and median for conjugate models (hand + Excel) 10. Bayesian estimation under squared error loss (SEL): posterior mean derivation and numerical check in Excel	

11. Bayesian estimation under absolute error loss (AEL): posterior median computation in Excel
12. Bayesian estimation under 0-1 loss: posterior mode and comparison with MLE in Excel
13. Bayesian estimation under LINEX loss: computation of Bayes estimator in Excel
14. Admissibility check: comparing Bayes risk of estimators for Binomial model in Excel
15. Empirical Bayes estimation: parametric EB for Normal model in Excel
16. Construction of equal-tails Bayesian credible intervals using Excel (Beta, Gamma, Normal posteriors)
17. Construction of HPD intervals: numerical search method in Excel
18. Computation of prior odds, posterior odds and Bayes factor for simple vs. simple hypotheses in Excel
19. Bayes factor calculation for simple vs. composite hypotheses: Normal model in Excel
20. Bayes factor for comparing two proportions using Beta-Binomial model in Excel
21. Demonstration of Lindley's paradox: numerical illustration in Excel
22. Bayesian hypothesis testing using JAMOVI (BayesFactor package): one-sample and two-sample t-tests
23. Posterior predictive distribution and prediction intervals in Excel
24. Bayesian simple linear regression: posterior computation for slope and intercept (conjugate prior) in Excel, Bayesian model comparison using BIC, Bayesian model averaging
25. Bayesian multiple linear regression: posterior mean vector computation in Excel, Bayesian model comparison using BIC
26. Bayesian analysis using C language: posterior distribution computation for Beta-Binomial model

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓						
CO2	✓	✓	✓		✓			
CO3	✓	✓		✓	✓			
CO4		✓	✓	✓	✓	✓		
CO5		✓		✓	✓	✓	✓	
CO6			✓	✓	✓	✓	✓	✓

Reference Books

1.	Berger, J. O. (1985). Statistical Decision Theory and Bayesian Analysis (2nd ed.). Springer, New York. ISBN: 978-0387960982.
2.	Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2013). Bayesian Data Analysis (3rd ed.). CRC Press. ISBN: 978-1439840955.
3.	Bolstad, W. M., & Curran, J. M. (2017). Introduction to Bayesian Statistics (3rd ed.). Wiley. ISBN: 978-1118593221.
4.	Lee, P. M. (2012). Bayesian Statistics: An Introduction (4th ed.). Wiley. ISBN: 978-1118332578.
5.	Robert, C. P. (2007). The Bayesian Choice (2nd ed.). Springer. ISBN: 978-0387715988.
6.	Bernardo, J. M., & Smith, A. F. M. (2009). Bayesian Theory. Wiley. ISBN: 978-0470016909.

7.	DeGroot, M. H., & Schervish, M. J. (2012). Probability and Statistics (4th ed.). Pearson. ISBN: 978-0321500465.
8.	Casella, G., & Berger, R. L. (2002). Statistical Inference (2nd ed.). Cengage Learning. ISBN: 978-0534243128.
9.	Ghosh, J. K., Delampady, M., & Samanta, T. (2006). An Introduction to Bayesian Analysis: Theory and Methods. Springer. ISBN: 978-0387400846.
10.	Christensen, R., Johnson, W., Branscum, A., & Hanson, T. E. (2011). Bayesian Ideas and Data Analysis. CRC Press. ISBN: 978-1439803547.
11.	Congdon, P. (2014). Applied Bayesian Modelling (2nd ed.). Wiley. ISBN: 978-1119951513.
12.	Migon, H. S., Gamerman, D., & Louzada, F. (2014). Statistical Inference: An Integrated Approach (2nd ed.). CRC Press. ISBN: 978-1439833575.
13.	Press, S. J. (2002). Subjective and Objective Bayesian Statistics (2nd ed.). Wiley. ISBN: 978-0471348474.
14.	Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics (12th ed.). Sultan Chand & Sons, New Delhi. ISBN: 978-8180544507.
15.	NPTEL / SWAYAM: Bayesian Inference – IIT Kanpur / IIT Bombay. Available at: swayam.gov.in

Teaching Methodology	Class work, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2703083102055003]
[Subject code for Practical-2703083102055004]

Major 5
M. Sc. (Statistics) Semester II
Course: ST-20052 Categorical Data Analysis

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Discipline Specific					
Course Code	ST-20052					
Course Level	500-599					
Course Title	Categorical Data Analysis					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					
Course Outcomes	CO1: Understand categorical data, nominal, ordinal and binary variables. CO2: Construct and interpret frequency tables, contingency tables and graphical summaries using Excel and JAMOVI. CO3: Apply Chi-square tests, Fisher's exact test and related procedures. CO4: Measure association using Phi, Contingency Coefficient, Cramer's V, Gamma and Kendall's Tau. CO5: Apply logistic regression models and interpret results. CO6: Use categorical data analysis in research, analytics and decision-making.					
Course Content						

Unit-1	**Categorical Data Structures, Contingency Tables and Inferential Procedures :**Introduction to categorical data and its role in statistical modelling; types of categorical variables: nominal, ordinal and binary variables; classification and coding of categorical data; one-way, two-way and multi-way contingency tables; marginal, joint and conditional distributions; graphical representation of categorical data using bar charts, segmented bar charts, mosaic plots and association plots. Sampling distributions for categorical data; multinomial distribution and its properties; estimation of cell probabilities; goodness-of-fit problems for categorical data; Pearson's Chi-square statistic and likelihood ratio Chi-square statistic; Chi-square goodness-of-fit test; Chi-square test of independence; Chi-square test of homogeneity; partitioning of Chi-square; residual analysis for contingency tables; standardized and adjusted residuals; Fisher's exact test; Yates' correction; McNemar test for paired categorical data; measures of discrepancy and model adequacy; interpretation of p-values and statistical significance. Applications of categorical data analysis in social sciences, public health, business analytics, actuarial science, official statistics and survey research.

	Unit-2	**Unit–2: Association Measures, Log-Linear Models and Logistic Regression:** Measures of association for nominal and ordinal categorical variables; Phi coefficient, Contingency coefficient, Cramér's V, Lambda coefficient, Gamma coefficient, Kendall's Tau-b and Tau-c; odds, odds ratio and relative risk; interpretation and confidence intervals for odds ratios and relative risks. Introduction to log-linear models; saturated and unsaturated models; model fitting and interpretation for contingency tables; goodness-of-fit tests for log-linear models; analysis of multi-way contingency tables. Binary response models; logistic regression model; logit transformation and logistic function; maximum likelihood estimation of logistic regression parameters; interpretation of regression coefficients; odds ratios and adjusted odds ratios; Wald test, likelihood ratio test and score test; model diagnostics; classification tables; measures of predictive accuracy. Multiple logistic regression; model building strategies; interaction effects; introduction to multinomial logistic regression and ordinal logistic regression; applications in epidemiology, healthcare analytics, market research, credit risk modelling, survey analysis and data science.

Course Code	STP-20052
Course Title	Practical in Categorical Data Analysis

Course Practical Content

1	Data Coding and Management of Categorical Variables
2	Frequency Distributions and Descriptive Analysis
3	Graphical Presentation of Categorical Data
4	One-Way and Two-Way Contingency Tables
5	Multi-Way Classification Tables
6	Estimation of Cell Probabilities and Marginal Distributions
7	Chi-Square Goodness-of-Fit Test
8	Chi-Square Test of Independence
9	Chi-Square Test of Homogeneity
10	Fisher's Exact Test and McNemar Test
11	Residual Analysis in Contingency Tables
12	Measures of Association for Nominal Data
13	Measures of Association for Ordinal Data
14	Odds Ratio and Relative Risk Analysis
15	Binary Logistic Regression
16	Multiple Logistic Regression
17	Model Diagnostics in Logistic Regression

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓		✓				✓
CO2	✓	✓	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books	1. Agresti, A. (2013). *Categorical Data Analysis* (3rd ed.). John Wiley & Sons, Hoboken, NJ. ISBN: 9780470463635. 2. Agresti, A. (2018). *An Introduction to Categorical Data Analysis* (3rd ed.). John Wiley & Sons, Hoboken, NJ. ISBN: 9781119405269. 3. Agresti, A. (2024). *Foundations of Linear and Generalized Linear Models*. John Wiley & Sons, Hoboken, NJ. ISBN: 9781119732075. 4. Agresti, A., & Finlay, B. (2009). *Statistical Methods for the Social Sciences* (4th ed.). Pearson Education, Boston. ISBN: 9780136030225. 5. Bishop, Y. M. M., Fienberg, S. E., & Holland, P. W. (2007). *Discrete Multivariate Analysis: Theory and Practice*. Springer, New York. ISBN: 9780387728056. 6. Christensen, R. (1997). *Log-Linear Models and Logistic Regression* (2nd ed.). Springer, New York. ISBN: 9780387947754. 7. Dobson, A. J., & Barnett, A. G. (2018). *An Introduction to Generalized Linear Models* (4th ed.). CRC Press, Boca Raton. ISBN: 9781138741515. 8. Faraway, J. J. (2016). *Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models* (2nd ed.). CRC Press. ISBN: 9781498720984. 9. Fox, J., & Weisberg, S. (2019). *An R Companion to Applied Regression* (3rd ed.). Sage Publications. ISBN: 9781544336473. 10. Friendly, M., & Meyer, D. (2016). *Discrete Data Analysis with R: Visualization and Modeling Techniques for Categorical and Count Data*. CRC Press, Boca Raton. ISBN: 9781498725835. 11. Hardin, J. W., & Hilbe, J. M. (2018). *Generalized Linear Models and Extensions* (4th ed.). Stata Press. ISBN: 9781597182539. 12. Harrell, F. E. (2015). *Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression and Survival Analysis* (2nd ed.). Springer, New York. ISBN: 9783319194240. 13. Hilbe, J. M. (2016). *Practical Guide to Logistic Regression*. Chapman & Hall/CRC Press, Boca Raton. ISBN: 9781498728355. 14. Hilbe, J. M. (2017). *Logistic Regression Models*. Chapman & Hall/CRC Press, Boca Raton. ISBN: 9781498728348. 15. Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). *Applied Logistic Regression* (3rd ed.). John Wiley & Sons, Hoboken, NJ. ISBN: 9780470582473. 16. James, G., Witten, D., Hastie, T., Tibshirani, R., & Taylor, J. (2023). *An Introduction to Statistical Learning: With Applications in R and Python* (2nd ed.). Springer. ISBN: 9783031387463. 17. Kleinbaum, D. G., & Klein, M. (2010). *Logistic Regression: A Self-Learning Text* (3rd ed.). Springer, New York. ISBN: 9781441917416. 18. Kuhn, M., & Johnson, K. (2019). *Feature Engineering and Selection: A Practical Approach for Predictive Models*. CRC Press. ISBN: 9781138079229. 19. Kuhn, M., & Silge, J. (2022). *Tidy Modeling with R*. O'Reilly Media. ISBN: 9781492096481. 20. Long, J. S., & Freese, J. (2014). *Regression Models for Categorical Dependent Variables Using Stata* (3rd ed.). Stata Press. ISBN: 9781597181112. 21. McCullagh, P., & Nelder, J. A. (2019 Reprint). *Generalized Linear Models* (2nd ed.). Chapman & Hall/CRC. ISBN: 9780412317606. 22. Menard, S. (2018). *Applied Logistic Regression Analysis* (3rd ed.). Sage Publications. ISBN: 9781506375526. 23. Powers, D. A., & Xie, Y. (2008). *Statistical Methods for Categorical Data Analysis* (2nd ed.). Emerald Group Publishing. ISBN: 9781848552241.

	24. Simonoff, J. S. (2003). *Analyzing Categorical Data*. Springer, New York. ISBN: 9780387953595. 25. Tutz, G. (2012). *Regression for Categorical Data*. Cambridge University Press, Cambridge. ISBN: 9780521136105.
Teaching Methodology	Class work, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

[Subject code for Theory-2703083102055005]
[Subject code for Practical-2703083102055006]

Major 5
M. Sc. (Statistics) Semester II
Course: ST-20053 Data Mining

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Major					
Course Subtype	Skill Development & Employability					
Subject Type	Intra-Disciplinary					
Course Code	ST-20053					
Course Level	500-599					
Course Title	Data Mining					
Credit	Theory:	2	Practical:	2	Total:	4
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the fundamental concepts, processes and applications of data mining.
CO-02:	Apply data preprocessing techniques for cleaning, transforming and preparing datasets.
CO-03:	Perform exploratory data analysis for identifying patterns and relationships in data.
CO-04:	Apply regression and classification techniques for predictive modelling.
CO-05:	Implement clustering methods for segmentation and pattern recognition.
CO-06:	Understand the principles and applications of neural networks in data analysis.
CO-07:	Apply genetic algorithms for solving optimization problems.
CO-08:	Analyse real-world datasets using data mining tools and statistical software.
CO-09:	Demonstrate the use of data mining techniques in research, industry and decision-making environments.

Course Content

Unit-1	**Introduction to Data Mining and Predictive Analytics**
	• Introduction to Data Mining
	• Knowledge Discovery in Databases (KDD)
	• Types of Data Mining
	• Data Mining Process
	• Data Pre-processing
	  o Data Cleaning
	  o Data Integration
	  o Data Transformation
	  o Data Reduction
	• Exploratory Data Analysis (EDA)
	• Applications of Data Mining

		• Introduction to Classification • Multiple Linear Regression • Stepwise Regression • Logistic Regression • Model Assessment and Validation

	Unit-2	**Clustering, Neural Networks and Evolutionary Computing**
		• Introduction to Clustering
		• Partitioning Methods
		• K-Means Clustering
		• Hierarchical Clustering
		• Cluster Validation
		• Introduction to Artificial Neural Networks
		• Structure and Working of Neural Networks
		• Applications of Neural Networks in Data Analysis
		• Introduction to Genetic Algorithms
		• Genetic Operators:
		  o Selection
		  o Crossover
		  o Mutation
		• Optimization using Genetic Algorithms
		• Applications of Data Mining in Business Analytics, Healthcare, Insurance and Research

Course Code	STP-20053
Course Title	Practical in Data Mining
Course Practical Content	

1.	Data Import and Data Cleaning.
2.	Handling Missing Values.
3.	Data Transformation and Normalization.
4.	Exploratory Data Analysis (EDA).
5.	Graphical Visualization of Data.
6.	Multiple Linear Regression - Stepwise Regression & Logistic Regression.
7.	Classification using Training and Test Datasets.
8.	Model Evaluation using Confusion Matrix.
9.	K-Means Clustering Hierarchical Clustering. Cluster Profiling and Interpretation. Principal Component Analysis for Data Reduction.
10.	Neural Network Modelling. Prediction using Neural Networks.
11.	Genetic Algorithm for Optimization Problems. Feature Selection using Genetic Algorithms.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓			✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓

CO5	✓	✓	✓	✓	✓		✓	✓
CO6	✓	✓	✓	✓	✓		✓	✓
CO7	✓	✓	✓	✓	✓		✓	✓
CO8	✓	✓	✓	✓	✓	✓	✓	✓
CO9	✓	✓	✓	✓	✓	✓	✓	✓

Reference Books

1. Han, J., Kamber, M. & Pei, J. (2022): Data Mining: Concepts and Techniques, 4th Edition, Morgan Kaufmann, ISBN: 9780128117606.
2. Witten, I. H., Frank, E., Hall, M. A. & Pal, C. J. (2016): Data Mining: Practical Machine Learning Tools and Techniques, 4th Edition, Morgan Kaufmann, ISBN: 9780128042915.
3. Larose, D. T. & Larose, C. D. (2014): Discovering Knowledge in Data: An Introduction to Data Mining, Wiley, ISBN: 9781118874059.
4. Tan, P. N., Steinbach, M., Karpatne, A. & Kumar, V. (2018): Introduction to Data Mining, 2nd Edition, Pearson, ISBN: 9780133128901.
5. Kantardzic, M. (2020): Data Mining: Concepts, Models, Methods and Algorithms, Wiley-IEEE Press, ISBN: 9781119516040.
6. Hastie, T., Tibshirani, R. & Friedman, J. (2017): The Elements of Statistical Learning, Springer, ISBN: 9780387848570.
7. James, G., Witten, D., Hastie, T. & Tibshirani, R. (2023): An Introduction to Statistical Learning with Applications in R, Springer, ISBN: 9783031387463.
8. Aggarwal, C. C. (2015): Data Mining: The Textbook, Springer, ISBN: 9783319141411.
9. James, G., Witten, D., Hastie, T. & Tibshirani, R. (2023): An Introduction to Statistical Learning with Applications in R, Springer, ISBN: 9783031387463 (Freely Available Online).
10. Hastie, T., Tibshirani, R. & Friedman, J. (2017): The Elements of Statistical Learning, Springer, ISBN: 9780387848570 (Freely Available Online).
11. Leskovec, J., Rajaraman, A. & Ullman, J. D. (2020): Mining of Massive Datasets, Cambridge University Press, ISBN: 9781108476348 (Freely Available Online).

Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments
Evaluation Method	Theory: Internal Assessment: 25 Marks + External Assessment: 25 Marks Practical: Internal Assessment: 25 Marks + External Assessment: 25 Marks

Skill Enhancement Course
M. Sc. (Statistics) Semester II
Course: ST-2006 Computer Programming Language C

Program Name	M. Sc. (Statistics)					
Semester	II					
NCrF Credit Level	6					
Course Type	Skill Enhancement Course (SEC)					
Course Subtype	Skill Development & Employability					
Subject Type	Intra-Disciplinary					
Course Code	ST-2006					
Course Level	500-599					
Course Title	Computer Programming Language C					
Credit	Theory:		Practical:		Total:	2
Effective From	Academic Year: 2026-27					

Course Outcomes

CO-01:	Understand the basic concepts, fundamentals, syntax and structure of C programming language including algorithms and flowcharts.
CO-02:	Understand and apply basic C programming concepts such as data types, variables, operators and expressions.
CO-03:	Design and develop programs involving conditional, looping and other control statements for solving computational and statistical problems.
CO-04:	Implement modular programming approaches using functions, parameter passing techniques and recursive functions.
CO-05:	Understand and apply different data structures such as arrays, structures and unions in problem-solving.
CO-06:	Develop programs involving data input-output operations, file handling and logical reasoning useful for statistical computing, research and data analysis.

Mapping between Cos and PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	✓	✓						✓
CO2	✓	✓	✓		✓			✓
CO3	✓	✓	✓	✓	✓			✓
CO4	✓	✓	✓		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓			✓
CO6		✓	✓	✓	✓	✓	✓	✓

Course Content

Unit-1	**Fundamentals of C Programming** • Introduction to Algorithms and Flowcharts • Types of Programming Languages • Introduction to C Language • Identifiers, Data Types, Constants and Variables • Arrays and Types of Arrays

	• Arithmetic, Unary, Relational, Logical, Assignment and Conditional Operators • Expressions and Evaluation of Expressions • Library Functions • Data Input and Output Functions • scanf(), printf(), gets() and puts() Functions • Introduction to Control Statements • if-else, switch, while, do-while and for Statements • break, continue and goto Statements
Unit-2	**Advanced Programming Concepts in C** • One Dimensional and Multi-Dimensional Arrays • Processing Array Elements • Passing Arrays to Functions • Strings and String Operations • Structure and Union • Defining and Processing Structures • Functions in C • Function Definition and Function Calling • Passing Arguments to Functions • Recursive Functions • Data Files in C • Opening, Reading, Writing and Closing Files

List of Exercise:

1. Implement a program that uses operators.
2. Implement a program that uses input and output functions.
3. Implement a program that is used to evaluate expression and display result.
4. Implement a program that read data from input device and display data in proper format.
5. Implement a program that uses the string functions.
6. Implement a program that uses the concept of selection statement.
7. Implement a program that uses the concept of looping construct.
8. Implement a program that uses the concept of array.
9. Implement a program that uses the concept of user defined function.
10. Implement a program that uses the concept of structure.
11. Implement a program related to file programming.

Implement a program related to recursion.

Reference Books

1.	Kernighan, B. W. & Ritchie, D. M. (1978): *The C Programming Language*, Prentice Hall, ISBN: 9780131101630.
2.	Mukhi, V. (1995): *The C Odyssey – Volume 6: Windows*, BPB Publications, ISBN: 9788170291688.
3.	Kochan, S. G. (2001): *Programming in C*, CBS Publishers & Distributors, ISBN: 9788177090734.
4.	Kochan, S. G. (2004): *Programming in C*, 3rd Edition, Sams Publishing, ISBN: 9780672326660.
5.	Kelly-Bootle, S. (1988): *Mastering Turbo C*, BPB Publications, ISBN: 9780895884626.
6.	Kanetkar, Y. (2006): *Let Us C*, 9th Edition, BPB Publications, ISBN: 9788183331630.
7.	Balagurusamy, E. (2011): *Programming in ANSI C*, 5th Edition, Tata McGraw Hill, ISBN: 9780070681828.
8.	Gottfried, B. S. (2010): *Programming with C*, 3rd Edition, Schaum's Outline Series, McGraw Hill, ISBN: 9780070145900.

		9.	Herbert Schildt, C: The Complete Reference, McGraw-Hill Education (India) Pvt Limited (2000), ISBN: 978-0070411838
		10.	Brian W. Kernighan AND Dennis Ritchie, C Programming Language, Pearson Education India, ISBN: 978-9332549449.
Teaching Methodology	Classwork, Discussion, Self-Study through SWAYAM, Seminar and/or Assignments		
Evaluation Method	Internal Assessment: 25 Marks External Assessment: 25 Marks **Note: Exam of Skill Enhancement course be taken on computers**		