Curricular Structure and Syllabi of Courses

Second Year of Two Year M.A./M.Sc. Statistics Programme
&
One year M.A./M.Sc. Statistics Programme

Under

PG Curricular Framework - Level 6.5

Proposed Syllabus
(Effective from AY 2026-27 based on NEP-2020)

Department of Statistics
Faculty of Mathematical Sciences
University of Delhi, Delhi – 110007

Programme Objectives and Outcomes

Programme Objectives:

The primary objectives of the M.A./M.Sc. Statistics Programme are to nurture students by enabling them to:

- Develop the aptitude to apply statistical tools to diverse data-generating fields and real-life problems.
- Gain the skills required to handle large datasets and perform data analysis using statistical software and programming languages.
- Acquire a wide range of statistical competencies- including problem-solving, project work, and presentation skills- so they can take on significant roles across various employment sectors and research fields.

Programme Outcomes:

Upon successful completion of the programme, students will be able to:

- Gain sound knowledge of both theoretical and practical aspects of Statistics.
- Apply statistical modelling and computational techniques effectively in practical scenarios.
- Explain complex statistical concepts to non-statisticians clearly and accurately.
- Manage and analyse large datasets using appropriate computational tools, and use the results to propose practical improvements.
- Pursue diverse career opportunities in research, industry, and academia.

M.A./M.Sc. Statistics Programme Details

Programme Structure

A. Two Year M.A./M.Sc. Statistics programme is a course divided into 2+2 semesters. A student is required to complete minimum **22** credits for completion of each semester.

Part	Year	Semester	Semester	Level
Part – I	First Year	Semester I	Semester II	6
Part – II	Second Year	Semester III	Semester IV	6.5

B. One Year M.A./M.Sc. Statistics programme is a course divided into 2 semesters. A student is required to complete minimum **22** credits for completion of each semester.

Part	Year	Semester	Semester	Level
Part – II	First Year	Semester I	Semester II	6.5

Course Credit Scheme of Part-II

Structure 1: PG Curricular Structure with only Course Work (In each Semester, 2 Core and either 3 DSE or 2 DSE + 1 GE are required)									
Semester	**Discipline Specific Core (DSC)**		**Discipline Specific Elective (DSE)**		**Generic Elective (GE)**		**Skill Based/ Specialized Laboratory (SB)**		**Total Credits**
	No. of Papers	Credits	No. of Papers	Credits	No. of Papers	Credits	No. of Papers	Credits	
Sem III/I	2	8	3	12	0	0	1	2	**22**
			2	8	1	4			
Sem IV/II	2	8	3	12	0	0	1	2	**22**
			2	8	1	4			
Total Credits for Second Year of Two Year/ One Year PG Programme									**44**

Structure 2: PG Curricular Structure with Course Work + Research (In each Semester 2 Core and either 2 DSE or 1DSE + 1GE are required)								
Semester	**Discipline Specific Core (DSC)**		**Discipline Specific Elective (DSE)**		**Generic Elective (GE)**		**Dissertation/ Academic project/ Entrepreneurship (DAE)**	**Total Credits**
	No. of Papers	Credits	No. of Papers	Credits	No. of Papers	Credits	Credits	
Sem III/I	2	8	2	8	0	0	6	**22**
			1	4	1	4		
Sem IV/II	2	8	2	8	0	0	6	**22**
			1	4	1	4		
Total Credits for Second Year of Two Year/ One Year PG Programme								**44**

Structure 3: PG Curricular Structure with Research only (DSE are to be chosen according to the area identified for research)								
Semester	**Discipline Specific Core (DSC)**		**Discipline Specific Elective (DSE)**		**Research Methods/Tools/ Writing (RTW)**		**One Intensive Problem based Research (IR)**	**Total Credits**
	No. of Papers	Credits	No. of Papers	Credits	No. of Papers	Credits	Credits	
Sem III/I	1	4	1	4	2 (a + b)	4	10	**22**
Sem IV/II	Nil	Nil	1	4	1 (c)	2	16	**22**
Total Credits for Second Year of Two Year/ One year PG Programme								**44**

a=Advanced Research Methodology; b=Tools for Research; c=Techniques of Research Writing

Note: Semester III & Semester IV refer to the Second Year of the Two Year PG Programme, while Semester I & Semester II refer to the One Year PG Programme.

Semester Wise Details

Structure 1: PG Curricular Structure with only Course Work
or
Structure 2: PG Curricular Structure with Course Work + Research

Semester III of Two Year/ Semester I of One Year Programme					
Discipline Specific Core Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSC 3a	Advanced Statistical Inference	3	1	0	4
DSC 3b	Multivariate Analysis	3	1	0	4

Discipline Specific Elective (DSE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSE 3a	Advanced Theory of Experimental Designs	3	0	1	4
DSE 3b	Operational Research	3	0	1	4
DSE 3c	Actuarial Statistics	3	0	1	4
DSE 3d	Stochastic Models	3	1	0	4
DSE 3e	Statistical Quality Management	3	0	1	4
DSE 3f	Advanced Survey Sampling	3	1	0	4
DSE 3g	Bayesian Inference	3	1	0	4

Generic Elective (GE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
GE 3a	Essentials of Survey Sampling and Experimental Designs	3	0	1	4
GE 3b	Applied Multivariate Statistics	3	0	1	4

Skill Based/Specialized Laboratory (SB) Courses (For Structure 1 Only)					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
SB 3a	Data Analysis Using R	0	0	2	2

Dissertation/Academic project/Entrepreneurship (For Structure 2 Only)		
Course Code	**Course Title**	**Credits**
DAE 3a	Dissertation*	6
DAE 3b	Academic project*	
DAE 3c	Entrepreneurship*	

******Choose only one.***

Semester IV of Two Year/ Semester II of One Year Programme					
Discipline Specific Core (DSC) Core Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSC 4a	Generalized Linear Models	3	1	0	4
DSC 4b	Econometrics	3	1	0	4

Discipline Specific Elective (DSE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSE 4a	Statistics in Finance	3	0	1	4
DSE 4b	Order Statistics	3	1	0	4
DSE 4c	Applied Stochastic Processes	3	1	0	4
DSE 4d	Advanced Statistical Computing and Data Mining	3	0	1	4
DSE 4e	Forestry and Environmental Statistics	3	1	0	4
DSE 4f	Statistical Decision Theory	3	1	0	4
DSE 4g	Survival Analysis	3	0	1	4

Generic Elective (GE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
GE 4a	Inferential Techniques	3	1	0	4

Skill Based/Specialized Laboratory (SB) Courses (For Structure 1 Only)					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
SB 4a	Data Analysis using SPSS	0	0	2	2

Dissertation/Academic Project/ Entrepreneurship (For Structure 2 Only)		
Course Code	**Course Title**	**Credits**
DAE 4a	Dissertation*	6
DAE 4b	Academic project*	
DAE 4c	Entrepreneurship*	

******Choose only one.***

Structure 3: PG Curricular Structure with Research only

Semester III of Two Year/ Semester I of One Year Programme					
Discipline-Specific Core Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSC 3c	Bayesian Inference	3	1	0	4

Discipline-Specific Elective (DSE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSE 3a	Advanced Theory of Experimental Designs	3	0	1	4
DSE 3b	Operational Research	3	0	1	4
DSE 3c	Actuarial Statistics	3	0	1	4
DSE 3d	Stochastic Models	3	1	0	4
DSE 3e	Statistical Quality Management	3	0	1	4
DSE 3f	Advanced Survey Sampling	3	1	0	4

Research Methods/Tools/ Writing					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
RTW 3a	Advanced Research Methodology	2	0	0	2
RTW 3b	Tools for Research	1	0	1	2

One Intensive Problem based Research		
Course Code	**Course Title**	**Credits**
IR 3a	To be decided	10

Semester IV of Two Year/ Semester II of One Year Programme					
Discipline Specific Elective (DSE) Courses					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
DSE 4a	Statistics in Finance	3	0	1	4
DSE 4b	Order Statistics	3	1	0	4
DSE 4c	Applied Stochastic Processes	3	1	0	4
DSE 4d	Advanced Statistical Computing and Data Mining	3	0	1	4
DSE 4e	Forestry and Environmental Statistics	3	1	0	4
DSE 4f	Statistical Decision Theory	3	1	0	4
DSE 4g	Survival Analysis	3	0	1	4

Research Methods/Tools/Writing (RTW)					
Course Code	**Course Title**	**Credits**			
		Theory	**Tutorial**	**Practical**	**Total**
RTW 4a	Techniques of Research Writing	1	0	1	2

One Intensive Problem based Research		
Course Code	**Course Title**	**Credits**
IR 4a	To be decided	16

Second Year of Two Year M.Sc. Statistics Programme

or

One Year M.Sc. Statistics Programme

Semester- III /Semester - I

Discipline Specific Core (DSC) Course

Discipline Specific Core (DSC) Course 3a: Advanced Statistical Inference

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSC 3a: Advanced Statistical Inference	4	3	1	0	NIL	NIL

Course Objectives:

- Understand the principles of parametric, non-parametric, and sequential estimation methods.
- Learn to compute point estimates and interval estimates using different estimation techniques.
- Develop skills in hypothesis testing for both simple and composite hypotheses.

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

- Understand consistency, CAN estimator and MLE.
- Understand UMPU tests, SPRT, OC and ASN.
- Understand non-parametric methods.

- Demonstrate proficiency in various parametric, non-parametric and sequential estimation techniques and testing procedures to deal with real-life problems.

Unit I (12 Hours)

Consistency and asymptotic relative efficiency of estimators, Consistent asymptotic normal (CAN) estimator, CAN estimator for one-parameter Cramer family, Cramer-Huzurbazar theorem, Method of maximum likelihood estimation, Method of scoring, Fisher lower bound to asymptotic variance.

Unit II (12 Hours)

Similar tests, Neyman structure, UMPU tests for composite hypotheses, Likelihood ratio test (LRT), Asymptotic distribution of LRT statistic, Consistency of large sample test.

Unit III (10 Hours)

Sequential tests-SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

Unit IV (11 Hours)

Non-parametric methods-estimation and confidence interval, U-statistics and their asymptotic properties, nonparametric tests-single sample location, location-cum-symmetry, randomness and goodness of fit problems.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Casella, G. and Berger, R.L. (2013). *Statistical Inference*, Cengage Learning.
2. Gibbons, J.D. and Chakraborti, S. (2021). *Nonparametric Statistical Inference*, Chapman and Hall/CRC Press.
3. Kale, B.K. (2005). *A First Course on Parametric Inference*, Alpha Science International.
4. Rohatgi, V. K. and Saleh, A.K.Md.E. (2015). *An Introduction to Probability and Statistics*, John Wiley & Sons.
5. Wald, A. (2004). *Sequential Analysis*, Dover Publications.

Suggested Readings:

1. Ferguson, T.S. (1967). Mathematical Statistics, Academic Press.
2. Lehmann, E.L. and Casella, G. (1998). *Theory of Point Estimation*, Springer.
3. Lehmann, E.L. and Romano, J.P. (2022). *Testing Statistical Hypotheses*, Springer.
4. Randles, R.H. and Wolfe, D.S. (1979). *Introduction to the Theory of Non-parametric Statistics*, John Wiley & Sons.
5. Rao, C.R. (1973). *Linear Statistical Inference and Its Applications*, Wiley Eastern Ltd.
6. Sinha, S. K. (1986). *Probability and Life Testing*, Wiley Eastern Ltd.
7. Zacks, S. (1971). *Theory of Statistical Inference*, John Wiley & Sons.

Discipline-Specific Elective (DSC) Course: 3b Multivariate Analysis

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSC 3b: Multivariate Analysis	4	3	1	0	NIL	NIL

Course Objectives:

- To introduce students to the analysis of observations on several correlated random variables for a number of individuals.
- Explore applications of multivariate techniques in fields such as Anthropology, Psychology, Biology, Medicine, Education, Agriculture, and Economics.

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

- Explain and apply fundamental theorems and concepts in multivariate analysis.
- Summarize, visualize, and interpret multivariate data.
- Appreciate the range of multivariate techniques available and their interconnections.
- Understand the relationship between multivariate and corresponding univariate techniques.
- Conduct statistical inference about multivariate means-including hypothesis testing and confidence regions.
- Use multivariate techniques appropriately and draw valid conclusions.

Unit I (12 Hours)

Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Matrix of normal distribution, Multivariate central limit theorem.

Unit II (10 Hours)

Wishart matrix, its distribution and properties, Distribution of sample generalized variance, Hotelling's T^2 statistic, its distribution and properties, applications in tests on mean vector for one and two multivariate normal populations, Mahalanobis' D^2 statistic.

Unit III (10 Hours)

Likelihood ratio test criteria for testing equality of mean and covariance matrices, Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao's U-statistic, its distribution and applications.

Unit IV (13 Hours)

Classification and Discrimination procedures for discrimination between two multivariate normal populations, Sample discriminant function, Classification rule based on expected cost of misclassification (ECM), Canonical Correlation Analysis, Principal Components Analysis, Elements of factor analysis and cluster analysis, Multivariate Analysis of Variance (MANOVA) of one-way classified data, Wilk's Lambda criterion.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, John Wiley & Sons.
2. Muirhead, R.J. (1982). *Aspects of Multivariate Statistical Theory*, John Wiley & Sons.
3. Rencher, A.C. and Christensen, W.F. (2012). *Methods of Multivariate Analysis*, John Wiley & Sons.

Suggested Readings:

1. Giri, N.C. (1977). *Multivariate Statistical Inference*, Academic Press.
2. Hair, J.F., Babin, B.J., Anderson, R.E. and Black, W.C. (2022). *Multivariate Data Analysis*, Cengage Learning.
3. Hardle, W.K. and Simar, L. (2015). *Applied Multivariate Statistical Analysis*, Springer.

4. Johnson, R.A. and Wichern, D.W. (2015). *Applied Multivariate Statistical Analysis*, Pearson.
5. Kshirsagar, A.M. (1996). *Multivariate Analysis*, Marcel Dekker.
6. Lawley, D.N. and Maxwell, A.E. (1971). *Factor Analysis as a Statistical Method*, Butterworths.
7. Rao, C.R. (1973). *Linear Statistical Inference and Its Applications*, John Wiley & Sons.

Discipline Specific Core (DSC) Course 3c: Bayesian Inference

Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3c: Bayesian Inference	4	3	1	0	NIL	NIL

Course Objectives:

- To provide the understanding of the fundamentals of Bayesian inference including concept of subjectivity and priors.
- Examine some simple Bayesian models and linear regression in a Bayesian framework.

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

- Treat "evidence" as value of observations and prescribe methods to deal rationally with it.
- Equip students with skills to carry out and interpret posterior and pre-posterior data based modeling and analyses.
- Compute probability that the theory in question could produce the observed data.
- Examine some simple Bayesian models and linear regression in a Bayesian framework.

Unit I (12 Hours)

Review of Basic Probability Concepts. Comparing Likelihood and Bayesian Approaches, Concept of Inverse Probability and Bayes Theorem. Classes of Prior Distributions. Conjugate Families for One Parameter Exponential Family Models, Models admitting sufficient statistics of fixed dimension.

Unit II (12 Hours)

Generalized Maximum Likelihood Estimate. Types of Loss Functions. Bayes estimation under various loss functions. Posterior Risk. Bayesian interval estimation: Credible intervals, HPD intervals, Comparison with classical confidence intervals. Situation specific case studies to conduct posterior analysis.

Unit III (11 Hours)

Prior and posterior odds. Bayes factor. Lindley's Paradox. Various types of testing hypothesis problems.

Unit IV (10 Hours)

Predictive density function, Regression Models.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Bernando, J.M. and Smith, A.F.M. (2000). *Bayesian Theory*, John Wiley & Sons.
2. Leonard, T. and Hsu, J.S.J. (1999). *Bayesian Methods, Cambridge University Press*.
3. Box, G.E.P. and Tiao, G.C. (1973). *Bayesian Inference in Statistical Analysis*, Addison & Wesley.

Suggested Readings:

1. Aitchison, J. and Dunsmore, I.R. (1975). *Statistical Prediction Analysis*, Cambridge University Press.
2. Berger, J. O., Bernardo, J. M. and Sun, D. (2023). *Objective Bayesian Inference*, World Scientific Publishing.
3. DeGroot, M.H. (1970). *Optimal Statistical Decisions*, McGraw Hill.
4. Kruschke, John. "Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan." (2014).
5. Lee, P. M. (1997). *Bayesian Statistics: An Introduction*, Arnold Press.
6. Robert, C.P. (2001). *The Bayesian Choice: A Decision Theoretic Motivation* (2^{nd} Ed.), Springer Verlag.

Discipline Specific Elective (DSE) Courses

Discipline Specific Elective (DSE) Course 3a: Advanced Theory of Experimental Designs

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3a: Advanced Theory of Experimental Designs	**4**	**03**	**00**	**01**	**NIL**	**Basic knowledge of Design of Experiments**

Course Objectives:

- To equip students with the ability to understand and apply experimental design techniques in real world problems and research.

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

- Understand the design and analysis of Partially Balanced Incomplete Block Designs and apply them in situations where balanced designs are not available.
- Construct Hadamard matrices, symmetric and asymmetric orthogonal arrays. Orthogonal arrays are used in industrial setups like automobile industry, computer experiments, cryptography, and quality improvement.
- Understand the concepts in general theory of Fractional Factorial Experiments and Various optimality criteria to obtain optimal designs.
- Apply techniques of Response surface methodology, construct designs for first and second order models, and appreciate the concepts of orthogonality, rotatability and blocking.
- Construct and analyse designs for mixture experiments that are useful in our day-to-day life, food industry, chemical industry, pharmaceutical companies.
- Understand and apply Crossover designs in practical situations.
- Understand the Robust Parameter designs and their use in quality improvement.

Unit I (13 Hours)

Partially balanced incomplete block (PBIB) designs, Resolvable and affine resolvable designs, Lattice designs, Construction and analysis of PBIB (2) designs.

Unit II (10 Hours)

General theory of fractional factorial Plans, Optimal designs- Various optimality criteria.

Unit III (10 Hours)

Hadamard matrices, Orthogonal arrays- symmetric and asymmetric orthogonal arrays and their constructions.

Unit IV (12 Hours)

Response surface designs- first and second order models, concepts of orthogonality, rotatability and blocking. Mixture experiments–models and designs, Cross-Over designs, Robust Parameter designs.

Essential Readings:

1. Bose, M. and Dey, A. (2009). *Optimal Crossover Designs*, World Scientific.
2. Cornell, John A. (2011*). Experiments with Mixtures*, John Wiley & Sons.
3. Dey, A. and Mukerjee, R. (1999). *Fractional Factorial Plans*, John Wiley & Sons.
4. Hedayat, A.S., Sloane, N. J.A. and Stufken, J. (2012). *Orthogonal Arrays: Theory and Applications*, Springer Science & Business Media.
5. Myers, R. H. and Montgomery, D.C. (2016). *Response Surface Methodology: Process and Product Optimization using Designed Experiments*, John Wiley & Sons.
6. Raghavarao, D. (1970). *Construction and Combinatorial Problems in Design of Experiments*, John Wiley & Sons.

Suggested Readings:

1. Das, M.N. and Giri, N.C. (2015). *Design and Analysis of Experiments*, New Age International Publishers.
2. Dey, A. (1986). *Theory of Block Designs*, John Wiley & Sons.
3. Dey, A. (2010). *Incomplete block designs*. World Scientific.
4. Hinkelmann, K. and Kempthorne, O. (2005). *Design and Analysis of Experiments*, Vol. II: Advanced Experimental Design, John Wiley & Sons.

5. Jones, B. and Kenward, M.G. (2003). *Design and Analysis of Cross-over Trials*. Chapman & Hall/CRC Press.
6. Montgomery, D.C. (2007). *Design and Analysis of Experiments*, John Wiley & Sons.
7. Wu, C.F.J. and Hamada, M. (2000). *Experiments: Planning, Analysis and Parameter Design Optimization*, John Wiley & Sons.

List of Practicals:

1. PBIB (2) designs.
2. Construction of Hadamard matrices.
3. Orthogonal arrays.
4. Fractional factorial designs.
5. Construction of optimal design.
6. Response surface designs.
7. Mixture designs.
8. Cross-over designs.
9. Robust Parameter designs.

Discipline Specific Elective (DSE) Course 3b: Operational Research

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3b: Operational Research	4	03	00	01	NIL	NIL

Course objectives:

- To introduce quantitative and model-based techniques for solving real-world problems.
- To develop the ability to formulate models and enhance skills in using models for effective and evidence-based decision-making.

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

- Identify and develop operational research models from the verbal description of the real system.
- Understand the characteristics of different types of decision-making environments and decision making approaches.
- Understand the mathematical tools that are needed to solve optimization problems.
- Analyze the queueing and inventory situations.
- Understand discrete event simulation and decision analysis with inclusion of modelling based on random events involving uncertainties.
- Conceptualize optimum event management through Network scheduling.

Unit I (12 Hours)

Definition and Scope of Operational Research, Phases in Operational Research, Different types of models and their construction. Simulation: Types and classifications. Pseudorandom Number Generation, Using random numbers to evaluate integrals, Generating discrete and continuous random variables: Inverse Transform Method, Acceptance-Rejection Technique, Composition Approach. Simulating discrete events.

Unit II (12 Hours)

Introduction to Decision Analysis: Pay-off table for one-off decisions and discussion of Decision criteria, Decision trees. Quadratic programming: Beale's and Wolfe's methods. Network Scheduling: CPM, PERT.

Unit III (11 Hours)

Queueing Theory: Steady state analysis of M/M/1, M/M/C queues, Method of stages for steady state solution of M/Er/1 and Er/M/1 queues.

Unit IV (10 Hours)

Inventory Management: Characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time. All units and incremental discounts. Single period stochastic models.

Essential Readings:

1. Gross, D., Shortle J.F., Thompson J.M. and Harris, C.M. (2008). *Fundamentals of Queueing Theory*, John Wiley & Sons.
2. Hadley, G. and Whitin, T.M. (1963). *Analysis of Inventory Systems*, Prentice Hall.
3. Ross, S. M. (2013). *Simulation*, Academic Press.
4. Taha, H. A. (2016). *Operations Research: An Introduction*, Prentice Hall.
5. Winston, W.L. and Goldberg, J.B. (2004). *Operations Research: Applications and Algorithms*, Thomson Brooks/Cole.

Suggested Readings:

1. Banks J. (1998). *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*, John Wiley and Sons.
2. Hillier, F.S. and Lieberman, G.J. (2001). *Introduction to Operations Research*, Irwin.

List of Practicals:

1. Random number generation of continuous distributions by using different methods like: Inverse Transform Method, Acceptance-Rejection Technique, Composition Approach.
2. Random number generation of discrete distributions by using different methods like: Inverse Transform Method, Acceptance-Rejection Technique, Composition Approach
3. Critical Path Method.
4. Program Evaluation and Review Technique.
5. Queueing Theory.
6. Inventory Management.

Discipline Specific Elective (DSE) Course 3c: Actuarial Statistics

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3c: Actuarial Statistics	4	03	00	01	NIL	Basic knowledge of probability

Course Objectives:

- To equip students with a comprehensive understanding of statistical methods and their applications in actuarial science.
- To learn modelling, analysis, and interpretation of data related to insurance, risk management, and financial forecasting.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

- Learn the basic concepts and statistical methods used in actuarial science.
- Learn modeling future life time distribution of human life.
- Understand various type of life insurance contract.
- Understand law of premium and reserves computations.

Unit I (11 Hours)

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions, risk and insurance, insurance products, reinsurance and its different types. Utility functions, expected value principle, expected utility criterion, types of utility function, insurance and utility theory. Individual risk models for aggregate claims. Collective risk models for short term.

Unit II (11 Hours)

Age at death random variable, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables, relation of life table functions to the survival function,

deterministic and random survivorship group, life table characteristics, recursion formulas, assumptions for fractional age, analytical laws of mortality, select and ultimate tables.

Unit III (12 Hours)

Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding, present value of a future payment. Life Insurance models: Models for insurance payable at the moment of death and at the end of the year of death - level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance. Life annuities: Various forms of annuities, continuous life annuities, discrete life annuities,

Unit IV (11 Hours)

Loss at issue random variable, fully continuous and fully discrete premiums, True mthly payment premiums, gross premiums. Calculation of prospective reserves using the future loss random variable, Recursions for reserves, fully continuous reserves, fully discrete reserves.

Essential Readings:

1. Deshmukh, S. and Prayag, V. (2025). *Actuarial Statistics: An Introduction Using R*, Universities Press.
2. Dickson, D.C.M., Hardy, M.R. and Waters, H.R. (2009). *Actuarial Mathematics for Life Contingent Risks*, Cambridge University Press.

Suggested Readings:

1. Booth, P.M (2004). *Modern Actuarial Theory and Practice*, Chapman & Hall.
2. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. Jones and Nesbitt, C.J. (1997). *Actuarial Mathematics*, Society of Actuaries.
3. Gerber, H.U. (2011). *Life Insurance Mathematics*, Springer, Swiss Association of Actuaries.
4. Mario V. Wüthrich, Michael Merz (2023). *Statistical Foundations of Actuarial Learning and its Applications*, Springer.
5. Rotar, V.I. (2015). *Actuarial Models: The Mathematics of Insurance*, CRC Press.

List of Practicals:

1. Utility function.
2. Expected value principle.
3. Individual risk model
4. Collective risk model
5. Life insurance and life annuities.
6. Premium and reserves calculation

Discipline Specific Core (DSE) Course 3d: Stochastic Models

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 3d: Stochastic Models	4	3	1	0	NIL	Basic knowledge of Probability

Course Objectives:

- To introduce fundamental principles of stochastic queueing and reliability models with intent.
- To evaluate and improve the efficiency of systems and its components related to various fields like engineering, manufacturing, and technology.

Course Learning Outcomes: On successful completion of the course students will be able to:

- Handle situations involving more than one random variable.
- Analyse the performance of reliability models.
- Model real life stochastic queueing situations.
- Analyse a network of queues with Poisson arrivals having general and exponential service requirements.
- Understand the concept of Maintainability and Availability in reliability modelling.
- Understand the use of statistical methods to evaluate and improve the reliability of systems in various fields like engineering, manufacturing etc.

Unit I (10 Hours)

Review of Stochastic processes: Markov process, Markov chain, Poisson Process, Birth and Death process. Stochastic queueing models: General concepts, Stationary distribution of Markovian queueing models with state dependent service, bulk arrivals and impatience.

Unit II (11 Hours)

Transient solution of birth and death exponential queueing models: M/M/1 and M/M/∞ with their measures of effectiveness including busy period distribution. Imbedded Markov chain technique and its use to solve the M/G/1 queueing models. Measures of effectiveness of M/G/1 queueing model.

Unit III (12 Hours)

Concept of reliability, Failures, failure modes: early age failures, wear out failures and chance failures and their representation with bathtub curve, Derivation of general reliability function, failure density function and mean time to failure (MTTF), Time dependent Hazard models, constant hazard models, linear hazard models, nonlinear hazard models. Derivation of two state reliability models using the Markov process.

Unit IV: (12 Hours)

Stochastic Reliability Models: Reliability of the multi-component stochastic System models, Maintainability and Availability: Concept of Maintainability, Maintainability function, Preventive maintenance, mean time between failure (MTBF), Availability, availability function, Derivation of availability function for: single component system with repair, two-unit parallel system with repair using Markov process.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Balagurusamy, E. (2017). *Reliability Engineering,* McGraw Hill Publications.
2. Billinton, R. and Allan, R.N. (2013). *Reliability evaluation of engineering systems: Concepts and techniques,* Springer.
3. Gross, D. and Harris C.M. (2008). *Fundamentals of Queueing Theory,* John Wiley & Sons.
4. Satty, T. L. (1983). *Elements of Queuing Theory with Applications,* Dover Publications.

Suggested Readings:

1. Bazovsky, I. (2013). *Reliability Theory and Practice*, Dover Publications.
2. Cooper, R.B. (1981). *Introduction to Queuing Theory,* North Holland, Elsevier.

3. Cox, D.R., and Miller, H.D. (1972). *The theory of stochastic processes*, Chapman and Hall.
4. Lewis, E. E. (1996). *Introduction to Reliability Engineering*, John Wiley & Sons.
5. Medhi, J. (2022). *Stochastic processes*, New Age International Publications.
6. Meeker, W.Q. and Escobar, L.A. (1998). *Statistical Methods for Reliability Data*, John Wiley & Sons.

Discipline Specific Elective (DSE) Course: 3e Statistical Quality Management

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3e: Statistical Quality Management	**4**	**3**	**0**	**1**	**NIL**	**Basic knowledge of statistical quality control**

Course Objectives:

- To understand the procedure which seeks to enhance theoretical and practical aspects of industrial management.
- To improve the quality of the output of a particular industrial process.

Course Learning Outcomes: After the completion of paper student will be able to:

- Identify and remove the cause of defects through different statistical quality management techniques.
- Practice how to minimize the variability in manufacturing and business process.
- Practice the different sampling plan for real life problem.

Unit I: (10 Hours)

Fundamentals of statistical concepts and techniques in quality control and improvement, Acceptance Control Chart, Multivariate Control Chart and Generalized Variance Chart.

Unit II: (12 Hours)

Acceptance sampling plans for inspection by variables for two sided specifications. Continuous Sampling plans. Bayesian sampling plans, designing a variable sampling plan with a specified OC curve, other variables sampling procedures, Sequential sampling plan.

Unit III: (12 Hours)

Process capability analysis and parametric estimation, confidence interval, and test of hypothesis for normally distributed characteristics. Process capability analysis for non-normal distributions, Process capability analysis using non-parametric approach.

Unit IV: (11 Hours)

Product and process design, fundamentals of experimental design, Taguchi method, loss functions, signal-to-noise ratio and performance measures, process modelling through regression analysis, Process capability analysis for auto-correlated process.

Essential Readings:

1. Grant, E.L. and Leavenworth, R.S. (2017). *Statistical Quality Control*, McGraw Hill.
2. Levinson, W.A. (2010). Statistical Process Control for Real-World Applications, CRC Press.
3. Montgomery, D.C. (2019). *Introduction to Statistical Quality Control*, Wiley.
4. Wetherill, G.B. (1977). *Sampling Inspection and Quality Control*, Halsted Press.

Suggested Readings:

1. Biswas, S. (1996). *Statistics of Quality Control, Sampling Inspection and Reliability*, New Age International Publishers.
2. Burr, I. W. (2020). *Statistical Quality Control Methods*: 16 (Statistics: A Series of Textbooks and Monographs), CRC Press.
3. Dale, B. H., Carol, B., Glen, B. H., Hemant, B.U. (2018). *Total Quality Management*, Pearson.
4. Duncan A.J. (1974). *Quality Control and Industrial Statistics*, Taraporewala & Sons.
5. Knoth S. and Schmid W. (2021). *Frontiers in Statistical Quality Control*, Springer.
6. Mittag, H. J. and Rinne, H. (1993). *Statistical Methods of Quality Assurance*, Chapman & Hall.
7. Montgomery, D.C. (2010). *Statistical Quality Control: A Modern Introduction*, John Wiley & Sons.
8. Ott, E.R. (2005). *Process Quality Control: Troubleshooting And Interpretation of Data Standards media*.
9. Wetherill, G.B. Brown, D.W. (1991). *Statistical Process Control Theory and Practice*, Chapman & Hall.

List of Practicals:

1. Acceptance Control chart.
2. Multivariate Control chart.
3. Continuous sampling plan
4. Bayesian sampling plan
5. Sequential sampling plan
6. Process capability analysis

Discipline-Specific Elective (DSE) Course 3f: Advanced Survey Sampling

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 3f: Advanced Survey Sampling	**4**	**3**	**1**	**0**	**NIL**	**Basic knowledge of Survey Sampling**

Course Objectives:

- To provide advanced techniques in survey sampling with practical applications in daily life.
- To provide accessible statistical tools for applying sampling strategies and methodologies.

Course Learning Outcomes: Upon successful completion of this course, students will be able to:

- Understand the non-existence of uniform estimators and repetitive surveys.
- Apply the re-sampling techniques for variance estimation independent and dependent random groups.
- Understand the design-based estimation procedures and double sampling technique for stratification.
- Understand the response and non- response techniques; Randomized Response Technique and a technique to predict non-observed residue under design and model-based model.
- Understand the model assisted sampling strategies; super population model.

Unit I (12 Hours)

Admissibility of Estimators; Non-existence of UMV estimators; Estimation of Median; Sampling on two or more successive occasions (Repetitive surveys); Double sampling for stratification; Re-sampling techniques for variance estimation-independent and dependent random groups, the Jackknife and the Bootstrap.

Unit II (12 Hours)

Small-area estimation; Design-based conditional approach; Direct and Indirect Estimators; Fay-Herriot Model. Ranked set sampling (RSS); RSS in parametric and non-parametric estimation; various versions of RSS. Adaptive Cluster Sampling (ACS); ACS based on order statistics.

Unit III (11 Hours)

Non-sampling errors; non-response and missing data; Randomized Response Techniques for one quantitative sensitive characteristic. Prediction of non-observed residual under fixed (design-based) and super-population (model-based) approaches.

Unit IV (10 Hours)

Model-assisted sampling strategies; Different types of Super-population models with optimal strategies based on them.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Cassel, C.M., Sarndal, C.E. and Wretman, J.H. (1977). *Foundations of Inference in Survey Sampling*, John Wiley & Sons.
2. Chaudhuri, A. and Mukerjee, R. (1988). *Randomized Response: Theory and Techniques*, Marcel Dekker Inc.
3. Hedayat, A.S. and Sinha, B.K. (1991). *Design and Inference in Finite Population Sampling*, John Wiley & Sons.
4. Rao, J.N.K. and Molina, I. (2015). Small area estimation, John Wiley & Sons.
5. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992). *Model Assisted Survey Sampling*, Springer.

Suggested Readings:

1. Chaudhari, A. and Stenger, H. (2005). *Survey sampling Theory and Methods*, Chapman and Hall.
2. Latpate, R., Kshirsagar, J., Gupta, V.K. and Chandra, G. (2020). *Advanced Sampling Methods*. Springer.
3. Levy, P.S. and Lemeshow, S. (2008). *Sampling of Populations: Methods and Applications*, John Wiley & Sons.

4. Muhopadhyay, P. (2009). *Survey Sampling*, Narosa Publishing House.
5. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). *Sampling Theory of Surveys with Applications*, Iowa State University Press.
6. Wolter, K.M. (2007). *Introduction to Variance Estimation*, Springer.
7. Wu, C. and Thompson, M.E. (2019). *Sampling theory and practice*. Springer.

Discipline Specific Elective (DSE) Course 3g: Bayesian Inference

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 3g: Bayesian Inference	**4**	**3**	**1**	**0**	**NIL**	**NIL**

Course Objectives:

- To provide the understanding of the fundamentals of Bayesian inference including concept of subjectivity and priors.
- Examine some simple Bayesian models and linear regression in a Bayesian framework.

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

- Treat "evidence" as value of observations and prescribe methods to deal rationally with it.
- Equip students with skills to carry out and interpret posterior and pre-posterior data based modeling and analyses.
- Compute probability that the theory in question could produce the observed data.
- Examine some simple Bayesian models and linear regression in a Bayesian framework.

Unit I (12 Hours)

Review of Basic Probability Concepts. Comparing Likelihood and Bayesian Approaches, Concept of Inverse Probability and Bayes Theorem. Classes of Prior Distributions. Conjugate Families for One Parameter Exponential Family Models, Models admitting sufficient statistics of fixed dimension.

Unit II (12 Hours)

Generalized Maximum Likelihood Estimate. Types of Loss Functions. Bayes estimation under various loss functions. Posterior Risk. Bayesian interval estimation: Credible intervals, HPD intervals, Comparison with classical confidence intervals. Situation specific case studies to conduct posterior analysis.

Unit III (11 Hours)

Prior and posterior odds. Bayes factor. Lindley's Paradox. Various types of testing hypothesis problems.

Unit IV (10 Hours)

Predictive density function, Regression Models.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Bernando, J.M. and Smith, A.F.M. (2000). *Bayesian Theory*, John Wiley & Sons.
2. Leonard, T. and Hsu, J.S.J. (1999). *Bayesian Methods, Cambridge University Press*.
3. Box, G.E.P. and Tiao, G.C. (1973). *Bayesian Inference in Statistical Analysis*, Addison & Wesley.

Suggested Readings:

1. Aitchison, J. and Dunsmore, I.R. (1975). *Statistical Prediction Analysis*, Cambridge University Press.
2. Berger, J. O., Bernardo, J. M. and Sun, D. (2023). *Objective Bayesian Inference*, World Scientific Publishing.
3. DeGroot, M.H. (1970). *Optimal Statistical Decisions*, McGraw Hill.
4. Kruschke, John. "Doing Bayesian data analysis: A tutorial with R, JAGS, and Stan." (2014).
5. Lee, P. M. (1997). *Bayesian Statistics: An Introduction*, Arnold Press.
6. Robert, C.P. (2001). *The Bayesian Choice: A Decision Theoretic Motivation* (2^{nd} Ed.), Springer Verlag.

Generic Elective (GE) Courses

Generic Elective (GE) Course 3a: Essentials of Survey Sampling and Experimental Designs

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
GE 3a: Essentials of Survey Sampling and Experimental Designs	**4**	**03**	**00**	**01**	**NIL**	**Knowledge of Basic Statistics**

Course Objectives:

- Equip students with essential tools and techniques of survey sampling.
- Develop skills to design and conduct experiments effectively.
- Train students to analyze and interpret data using appropriate statistical methods.

Course Learning Outcomes: After completing this course, the students will be able to:

- Plan and conduct a sample survey.
- Choose an appropriate sampling design for conducting a sample survey.
- Understand the basic concepts design of experiments.
- Understand and use simple and complex designs.
- Analyse and interpret the data from designed experiments.

Unit I (8 Hours)

Population and sample, types of sampling, basic principles of sample survey, steps involved in survey sampling, sampling and non-sampling errors, sample size determination.

Unit II (12 Hours)

Simple random sampling (SRS) with and without replacement, stratified sampling- equal, proportional and Neyman allocation, systematic sampling, presence of linear trend, large scale surveys.

Unit III (11 Hours)

Linear regression, least squares estimators and their properties, analysis of variance (ANOVA), ANOVA for fixed effect models - one-way and two-way classified data, Analysis of Covariance (ANCOVA).

Unit IV (14 Hours)

Design of experiments- role, terminology, basic principles, uniformity trials, error control, determination of optimal plot size, Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), missing plot technique, Balanced Incomplete Block Design (BIBD), Factorial experiments – 2^n ($n \leq 5$) and 3^n ($n \leq 3$) designs.

Essential Readings:

1. Cochran, W.G. (2011). *Sampling Techniques*, John Wiley & Sons.
2. Das, M.N. and Giri, N.C. (2015). *Design and Analysis of Experiments*, New Age International Publishers.
3. Montgomery, D.C. (2007). *Design and Analysis of Experiments*, Ninth Edition, John Wiley & Sons.
4. Mukhopadhyay, P. (1998). *Theory and Methods of Survey Sampling*, Prentice Hall of India.
5. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C. (1984). *Sampling Theory of Surveys with Applications,* Lowa State University Press, Lowa, USA.

Suggested Readings:

1. Bethlehem, J. (2009). *Applied Survey Methods: A Statistical Perspective*, John Wiley & Sons.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). *Fundamentals of Statistics*, Vol. II, World Press, Kolkata.
3. Murthy M.N. (1977). *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta.
4. Mukhopadhyay, P. (2011). *Applied Statistics,* 2nd ed., Books and Allied (P) Ltd.
5. Scheaffer, R.L., Mendenhall, W., Ott, R.L. and Gerow, K. (2012). *Elementary Survey Sampling*, 7th ed., Cengage Learning.

List of Practicals:

1. SRS with and without replacement
2. Stratified sampling- equal, proportional and Neyman's allocation.
3. Systematic sampling.
4. Simple Linear regression.
5. ANOVA.

6. ANCOVA.
7. CRD
8. RBD
9. LSD
10. BIBD
11. Factorial designs.

Generic Elective (GE) Course 3b: Applied Multivariate Statistics

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 hours)		
GE 3b: Applied Multivariate Statistics	**4**	**3**	**0**	**1**	**NIL**	**Basic knowledge of Probability Theory and Linear Algebra**

Course Objectives:

- Introduces students to multivariate statistical techniques used in applied research.
- Emphasis on understanding concepts, interpreting results, and applying methods to real data using statistical software and tools.

Course Learning Outcomes: After successful completion of this course, the students will be able to:

- Understand multivariate data structures and matrix notation.
- Apply techniques for data reduction and visualization.
- Analyze relationships among multiple variables simultaneously.
- Use multivariate methods for classification, prediction, and inference.
- Interpret multivariate output from software in practical contexts.

Unit I (9 hours)

Concept of bivariate and trivariate data, covariance and correlation (Pearson's r, correlation matrix), scatterplots, correlation heatmaps, pairwise plots, idea of random vectors and covariance matrix (without derivations), concept of multivariate normal distribution: definition, properties, and testing for normality, idea of linear combinations and marginal distributions (concept only), outlier detection using Mahalanobis distance, checking multivariate normality (graphical and numerical methods).

Unit II (12 hours)

Multiple and partial correlation; multiple linear regression – concept, interpretation of coefficients, R^2, adjusted R^2, and residuals; idea of multicollinearity; model checking (linearity, normality, and homoscedasticity) and visualization using diagnostic plots; introduction to canonical correlation – concept and interpretation; practical interpretation of correlation and regression output.

Unit III (10 hours)

Principal Component Analysis (PCA): eigenvalues and eigenvectors, total variance explained, scree plot, component loadings, interpretation, Factor Analysis: common factor model, estimation of loadings, rotation (varimax), communalities, Comparison of PCA and Factor Analysis, use of software to perform PCA/FA and interpret outputs.

Unit IV (14 hours)

Concept of grouping similar observations; hierarchical clustering (concept, dendrogram interpretation) and k-means clustering (steps, centroids, and output interpretation), Discriminant Analysis: concept of classifying observations into known groups using predictor variables; linear discriminant function, idea of classification accuracy, confusion matrix, and misclassification rate; Comparison between clustering (unsupervised) and discriminant (supervised) methods, overview of real-world applications and interpretation.

Essential Readings:

1. Everitt, B.S. and Hothorn, T. (2011). *An Introduction to Applied Multivariate Analysis with R*, Springer.
2. Hair, J.F., Babin, B.J., Anderson, R.E. and Black, W.C. (2022). *Multivariate Data Analysis*, Cengage Learning.
3. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2021). *An introduction to statistical learning: with applications in R*, Springer.
4. Johnson, R.A. and Wichern, D.W. (2019). *Applied Multivariate Statistical Analysis*, Pearson.

Suggested Readings:

1. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, John Wiley & Sons.
2. Bakker, J.D. (2024). *Applied Multivariate Statistics in R.* University of Washington.
3. Chatfield, C. and Collins, A.J. (1980). *Introduction to Multivariate Analysis*, Chapman & Hall.

4. Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics*, Sage Publications.
5. Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E (2010). *Multivariate Data Analysis*, Pearson.
6. Izenman, A.J. (2008). *Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning*, Springer.
7. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2021). *An Introduction to Statistical Learning with Applications in R*, Springer.
8. Rao, C.R. (1973). *Linear Statistical Inference and Its Applications*, Wiley.
9. Rencher, A.C. and Christensen, W.F. (2012). *Methods of Multivariate Analysis*, John Wiley & Sons.

List of Practicals:

1. Data Import and Exploration
2. Visualization and Correlation Matrix
3. Multiple and Partial Correlation
4. Multiple Regression and Diagnostics
5. Principal Component Analysis (PCA)
6. Factor Analysis
7. Cluster Analysis (Hierarchical & K-Means)
8. Discriminant Analysis and Classification

Skill Based (SB) Courses

Skill Based/Specialized Laboratory (SB) Course 3a: Data Analysis Using R

Structure 1: PG Curricular Structure with only Course Work

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (00 Hours)	Tutorial (00 Hours)	Practical (60 hours)		
SB 3a: Data Analysis Using R	**2**	**0**	**0**	**2**	**NIL**	**NIL**

Course Objectives:

- To enhance the programming skills and working knowledge of R software.
- Equip students for data management and optimization using R.

Course Learning Outcomes: After successful completion of this course, the students will be able to:

- Understand R programming for data analysis
- Accessing R packages and use different functions in R
- Visualize and summarize the data using statistical functions and graphs
- Develop computational skills for the generation of random samples
- Perform MLEs and application problems based on the fitting of a suitable distribution.
- Design and analyse incomplete block designs.

Unit I: (14 Hours)

Introduction to R, R data structures, kernel density plots, ggplots2 package. Panel display, surface plots, contour plots, plots in 2-D and 3-D. Exploratory data analysis of the empirical distribution function and its properties, quantile function, confidence interval of quantiles of order p, tolerance and convergence. Kernel function for density estimation.

Unit II: (14 Hours)

The inverse transformation for the generation of random variables from discrete, continuous and exponentiated distributions. One-dimensional optimization, Maximum Likelihood Estimation through ***nlm,*** and ***optim*** packages. Non-parametric tests: Kruskal-Wallis test, Wilcoxon, Mann-Whitney test.

Unit III: (14 Hours)

Hypothesis testing of one and paired sample t-test. ANOVA: Fixed, Random and Mixed effect models. Incomplete and Confounded Block Designs: Balanced Incomplete Block (BIB) Designs, Confounded 2^K and 2^{k-p} Designs.

Unit IV: (14 Hours)

Cluster analysis: Hierarchical Cluster analysis, K-Means Cluster Analysis, Factor analysis Principal Components Analysis, Discriminant Analysis.

Essential Readings:

1. Davies, T.M. (2016). *The Book of R: A First Course in Programming and Statistics*, No Starch Press.
2. Lawson, J. (2015). *Design and Analysis of Experiments with R*, Chapman and Hall/CRC Press.
3. Rizzo, M.L. (2019). *Statistical Computing with R*, Chapman & Hall/CRC Press.

Suggested Readings:

1. Crawley, M.J. (2023). *The R Book*, John Wiley & Sons.
2. Gardener, M. (2017). *Beginning R: The statistical programming language*, John Wiley & Sons.
3. Kabacoff, R.I. (2015). *R in Action: Data Analysis and Graphics in R*, Manning Publications.

Research Methods/Tools/ Writing (RTW) Courses

Research Methods/Tools/ Writing (RTW) Course 3a: Advanced Research Methodology

Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (30 Hours)	Tutorial (00 Hours)	Practical (00 Hours)		
RTW 3a: Advanced Research Methodology	**2**	**2**	**0**	**0**	**NIL**	**NIL**

Course Objectives:

- To introduce students to the concepts, scope, and ethics of research in Statistics.
- Develop skills for conducting literature reviews, conceptualising research designs,
- Develop understanding of historical and contemporary contexts of statistical contributions in the development of sciences.

Course Learning Outcomes: After successful completion of this course, the students will be able to:

- Understand the process of research and its underlying ethical considerations.
- Conduct literature surveys using primary sources and secondary databases.
- Design and execute a small-scale research project using appropriate statistical methodology.
- Understand evolution of Statistics and appreciate statistical heritage.

Unit I (7 Hours)

Evolution of Statistics as a discipline, Important milestones in statistical research, Contributions of statisticians and statistical institutions in allied sciences, Importance and necessity of ethical considerations in statistical research.

Unit II (9 Hours)

Accessing literature: Manual, Scientific reports and Statistical Database, Electronic: e-journals, e-books, and Online Database, Referencing Style: Modern Language Association (MLA), American Psychological Association (APA), Chicago Manual of Style (Chicago), Harvard

Referencing Style (Harvard), Vancouver Referencing Style (Vancouver). Impact Factor as per Journal Citation Reports (JCR), Scimago Journal Rank (SJR), and cite score. Multi-Criteria Decision-Making (MCDM) methods like Technique for Order Preference by Similarity to Ideal Solution **(**TOPSIS), Grey Relational Analysis (GRA) etc. Selection of Journals vis-à-vis specific research area/ topic.

Unit III (8 Hours)

Concept of Inductive and Deductive inference in Statistics, Application and formulation of statistical inferences in various research domains, Mode of conducting field research and operationalisation of variables. Textual analysis of sub-topics in analytic research.

Unit IV (7 Hours)

Inverse probability, Iterative techniques as approximation to complex differential and integral forms.

Essential Readings:

1. Cox, D. R. (2006). *Principles of Statistical Inference*, Cambridge University Press.
2. Hald, A. (1999). *A History of Mathematical Statistics from 1750 to 1930*, John Wiley & Sons.
3. Krippendorff, K. (2018). *Content analysis: An introduction to its methodology*, Sage publications.
4. Kumar, R. (2018). *Research Methodology: A Step-by-Step Guide for Beginners*, SAGE Publications.

Suggested Readings:

1. Beveridge, W.I.B. (2017). *The art of scientific investigation*, Edizioni Savine.
2. Chambers, J. (2008). *Software for Data Analysis: Programming with R*, Springer.
3. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K.R. (1992). *Glilmpses of India's Statistical Heritage*, Wiley Eastern Limited, New Delhi.
4. Jeffreys, H. (1998). *The theory of probability*, OuP Oxford.

Research Methods/Tools/ Writing (RTW) Course 3b: Tools for Research

Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (15 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
RTW 3b: Tools for Research	2	1	0	1	NIL	NIL

Course Objectives:

- To develop practical skills for conducting statistical research using modern computational tools.
- Familiarise students document preparation, data analysis, and visualisation tools.
- To equip students for applying programming and numerical methods to data-based analytics.

Course Learning Outcomes:

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

- Perform advanced data analysis using SPSS, Excel, and Minitab/Stata.
- Handle the data from various well known platforms.
- Apply simulation, MCMC, and bootstrap methods in statistical computations.
- Solve algebraic, transcendental, and matrix problems using numerical methods.

Unit I (7 hours)

Use of Statistical spreadsheets for data management and analysis: SPSS, Excel/ Minitab/STATA.

Unit II (7 hours)

Data handling through analytic platforms, Eviews/ITSM.

Unit III (8 hours)

Methodology of Inverse Transformation method and Acceptance-Rejection algorithm for simulating data from some selected statistical distributions.

Unit IV (8 hours)

Algorithms for solving algebraic and transcendental equations, Numerical integration, Matrix operations and applications in Statistics by using R/ Python.

Essential Readings:

1. Bass, I. (2007). *Six Sigma Statistics with Excel and Minitab (Vol. 7, p. 386),* New York, McGraw-Hill.
2. Bryman, A. & Cramer, D. (2012). *Quantitative Data Analysis with IBM SPSS 17, 18 & 19: A Guide for Social Scientists,* Routledge.
3. McKinney, W. (2022). *Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter*, O'Reilly Media.
4. Pannerselvam, R. (2006). *Research Methodology*, Prentice-Hall of India Pvt.
5. Rizzo, M.L. (2019). *Statistical Computing with R*, Chapman & Hall/CRC Press.

Suggested Readings:

1. Press, W.H., Teukolsky, S.A., Vetterling, W.T. and Flannery, B.P (2007). *Numerical Recipes: The Art of Scientific Computing,* Cambridge university press.
2. Rasch, D., Pilz, J., Verdooren, L.R. and Gebhardt, A. (2019). *Exploratory Data Analysis in Business and Economics: An Introduction Using SPSS, Stata, and Exce*, Springer Cham.
3. Robert, C.P. and Casella, G. (2004). *Monte Carlo Statistical Methods*, Springer Science, Springer.

Practical:

- Exploring use of statistical tools and techniques using software taught in class.

Semester-IV/ Semester-II

Discipline Specific Core (DSC) Course

Discipline-Specific Core (DSC) Course 4a: Generalized Linear Models

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSC 4a: Generalized Linear Models	4	03	01	00	NIL	Basic knowledge of Linear Models

Course Objectives:

- To equip students with the ability to learn and use linear and generalized linear models for normal and non-normal responses.

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

- Use linear models, apply data transformations, and appreciate the need of generalized linear models.
- Use logistics and Poisson regression models.
- Understand the concept of deviance, analysis of deviance, Lack-of-Fit tests in Logistic and Poisson regression, and the concept of overdispersion.
- Use Log linear models for contingency tables, and likelihood ratio tests for various hypotheses testing,
- Understand complete independence, marginal and conditional independence, and partial association.
- Understand graphical and non-graphical models.
- Use the concepts of Generalized Linear Models in real life problems.
- Understand and apply Quasi likelihood.

Unit I (8 Hours)

Review of linear regression models, ML estimation, Residual analysis, Transformation of response variable- Box-cox method, Introduction to generalized linear models (GLMs).

Unit II (9 Hours)

Logistic and Poisson regression- Logistic regression model, ML estimation, Goodness-of-Fit tests (Concept of deviance), analysis of deviance, Lack-of-Fit tests in logistic regression. Concept of overdispersion in logistic regression. Poisson regression, MLE for Poisson regression, applications in Poisson regressions.

Unit III (14 Hours)

Log linear models for contingency tables- interpretation of parameters, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, and partial association. Graphical and decomposable models.

Unit IV (14 Hours)

Family of Generalized Linear Models- Exponential family of distributions, Formal structure for the class of GLMs, Link functions, Likelihood equations for GLMs, Important distributions for GLMs, A class of link functions- the power function, Inference and residual analysis for GLMs, Quasi likelihood.

Tutorial

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Christensen, R. (2025). *Log-linear Models and Logistic Regression*, Springer.
2. McCullagh, P. and Nelder, J.A. (1989). *Generalized Linear Models*, Chapman and Hall.
3. Myers, R.H., Montgomery, D.C., Vining, G.G., and Robinson, T. J. (2012). *Generalized Linear Models with Applications in Engineering and the Sciences*, John Wiley & Sons.
4. Zelterman, D. (2006). *Models for Discrete Data,* Oxford University Press Inc.

Suggested Readings:

1. Agresti, A. (2002). *Categorical Data Analysis*, John Wiley & Sons.
2. Bates. D.M. and Watts, D.G. (2007). *Nonlinear Regression Analysis and its Applications*, Wiley-Interscience.
3. Collett, D. (2003). *Modeling Binary Data*, Chapman and Hall.
4. Dobson, A.J. and Barnett, A.G. (2018). *Introduction to Generalized Linear Models*,

Chapman and Hall/CRC.

5. Green, P.J. and Silverman, B.W. (1994). *Nonparametric Regression and Generalized Linear Models*, Chapman and Hall.
6. Hastie, T.J. and Tibshirani, R.J. (1990). *Generalized Additive Models*, Chapman and Hall.
7. Hosmer, D.W., Lemeshow, S. and Sturdivant, R.X. (2013). *Applied logistic regression*, John Wiley & Sons.
8. Lindsey, J. K. (1997). *Applying generalized linear models*, Springer.
9. McCulloch, C.E. and Searle, S.R. (2004). *Generalized, Linear and Mixed Models*, John Wiley & Sons.

Discipline-Specific Core (DSC) Course 4b: Econometrics

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSC 4b: Econometrics	4	3	1	0	NIL	NIL

Course Objectives:

- To apply general linear model (GLM) and Ordinary Least Squares (OLS) on Economic data sets.
- To test hypothesis for regression coefficients under Bayes paradigm.
- Model building and evaluation.
- Assessment of lag length using statistical criteria and economic reasoning.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

- Acquire knowledge of various advanced econometric models, estimation methods and related econometric theories.
- Conduct econometric analysis of data.
- Apply statistical techniques to model relationships between variables and make predictions.

Unit I (11 Hours)

Econometrics: Review of GLM and ordinary least squares, GLM with stochastic regressors, Instrumental variables (I.V): estimation, consistency property, asymptotic variance of I.V estimators. Bayesian analysis of linear model with non-informative priors and conjugate priors.

Unit II (12 Hours)

Distributed lag models, polynomial lag models, Almon's lag model, determination of degree of polynomial and lag length. Adaptive expectation model, partial adjustment model, compound geometric lag model, and methods of estimation.

Unit III (11 Hours)

The Granger Causality Test, simultaneous-equation models: identification problems. Restrictions on structural parameters – rank and order condition for identification.

Unit IV (11 Hours)

Simultaneous-equation methods: Estimation - Recursive systems, two stage least squares (2SLS) estimators, and full information maximum likelihood (FIML).

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Greene, W.H. (2003). *Econometric Analysis*, Prentice Hall.
2. Gujarati, D.N. and Porter, D.C. (2009). *Basic econometrics*, McGraw-Hill.
3. Maddala, G.S. (2001). *Introduction to Econometrics*, John Wiley & Sons.
4. Ramanathan, R. (2002). *Introductory Econometrics with Applications*, Harcourt College Publishers.

Suggested Readings:

1. Baltagi, B. H. (2021). *Econometrics*, Springer
2. Hayashi, F. (2000). *Econometrics*, Princeton University Press.
3. Johnston, J. (1984). *Econometric Methods*, McGraw Hill.
4. Kennedy, P. (2008). *A Guide to Econometrics*, Blackwell Publishing.
5. Kment, J. (1986). *Elements of Econometrics*, Mac Millan.

Discipline Specific Elective (DSE) Courses

Discipline Specific Elective (DSE) Course 4a: Statistics in Finance

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 4a: Statistics in Finance	04	03	00	01	NIL	Basic knowledge of Probability Theory

Course Objectives:

- To introduce students to a range of various market-related financial instruments.
- Learn selected statistical models used to analyze and interpret market behavior.

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

- Understand mean behavior, fluctuations and cycles of financial markets.
- Understand concept of derivatives in markets.
- To model price of an asset that exhibits random changes as new market information arrives.
- To understand and differentiate between mean square calculus and it calculus.
- To conduct analytic and predictive study on market data.

Unit I (11 Hours)

Derivatives: Forward Contract, Call Option, Put Option, Zero Coupon bond, Discount bond, No arbitrage, Binomial tree model, Binary one-period Model, Arbitrage relations for option management.

Unit II (11 Hours)

Random walk, Geometric random walk, Brownian motion with examples for each from financial markets. Stochastic integrals and differential equations.

Unit III (11 Hours)

Stock price as a stochastic process. Itô's lemma. Black-Scholes option pricing model.

Expectations and efficient markets. Volatility. Value at Risk.

Unit IV (12 Hours)

Econometric models for stock price, exchange rate, term structure and options. Market price of risk. ARCH (q) and GARCH (p, q) models, their estimation and applications.

Essential Readings:

1. Franke J., Hardle W.K. and Hafner C.M. (2011) Statistics of Financial Markets: An Introduction, 3rd ed, Springer.
2. Hull, J. C., and Basu, S. (2021). Options, futures, and other derivatives. Pearson Education India.
3. Tankov, P. (2010). Financial Modeling with Lèvy Processes, e-Book.

Suggested Readings:

1. Lamberton, D. and Lepeyre, B. (2008). Introduction to Stochastic Calculus Applied to Finance, 2nd ed., Chapman and Hall/CRC Press.
2. Privault, N. (2014). Stochastic Finance –An Introduction with Market Examples, Chapman and Hall/CRC. Financial Mathematics Series, CRC Press.

List of Practicals:

1. Payoff graph under given call strategies with varying exercise prices and option transaction.
2. Simulation of (i) a group of parallel straight lines, whose points form a lattice (ii) Fibonacci generators.
3. Generate a pair of standard normal variate by using (i) Box-Muller method (ii) Marsaglia method.
4. Verify (i) whether prices of options are consistent under portfolio change (ii) arbitrage opportunities' existence and /or occurrence.
5. Study impact of stock price on insured and non-insured portfolio values and returns.
6. To determine number of stocks and/or options for investing and their delivery price.
7. Calculation of option price for binary one-period model.
8. Problems based on real-market situations which follow Brownian motion.
9. Estimation and fitting of ARCH (q) and GARCH (p, q) model.

Discipline-Specific Elective (DSE) Course 4b: Order Statistics

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 4b: Order Statistics	**4**	**3**	**1**	**0**	**NIL**	**NIL**

Course Objectives:

- To make the students aware of the properties and applications of order statistics, record values and generalized order statistics**.**

Course Learning Outcomes: On successful completion of the course, students will be able to:

- Find the basic distribution theory of order statistics in both continuous and discrete cases, including the distributions of the sample range and other systematic statistics.
- Learn how to obtain distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals for population distributions based on order statistics.
- Understand the distribution-free bounds for moments of order statistics and of the range.
- Derive the recurrence relations and identities for the moments of order statistics obtained from arbitrary (discrete or continuous) populations and from selected specific distributions.
- Find the distributions of order statistics for independent but non-identically distributed random variables and learn about the joint and marginal distributions of order statistics from a sample containing a single outlier.
- Learn about the basic concepts of record values and generalized order statistics.

Unit I (12 Hours)

Introduction to order statistics, Basic distribution theory, Joint and marginal distributions of order statistics in the continuous case, Distribution of the range and other systematic statistics, Conditional distributions, Order statistics as a Markov Chain, Order statistics for a discrete parent, Examples based on discrete and continuous distributions.

Unit II (12 Hours)

Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals, Distribution-free bounds for moments of order statistics and of the range, Approximations to moments in terms of the quantile function and its derivatives.

Unit III (10 Hours)

Moments of order statistics, Recurrence relations and identities for moments of order statistics from an arbitrary distribution, Recurrence relations for moments of order statistics from some specific distributions.

Unit IV (11 Hours)

Order statistics for independently and not identically distributed variates. Order statistics from a sample containing a single outlier. Concepts of record values and generalized order statistics.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Arnold B.C., Balakrishnan N. and Nagaraja H.N. (1998): *Records*. John Wiley & Sons.
2. Arnold, B. C., Balakrishnan, N. and Nagaraja H.N. (2008). *A First Course in Order Statistics*, SIAM Publishers.
3. David, H. A. & Nagaraja, H. N. (2003). *Order Statistics*, John Wiley & Sons.
4. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). *Ordered Random variables: Theory and Applications*, Springer.

Suggested Readings:

1. Ahsanullah, M. (1995): *Record Statistics*, Nova Science Publishers.
2. Ahsanullah, M. (2004): *Record Values-Theory and Applications*, University Press of America.
3. Ahsanullah, M., Nevzorav, V.B. and Shakil, M. (2013). *An Introduction to Order Statistics*, Atlantis Press.
4. Arnold, B.C. & Balakrishnan, N. (1989). *Relations, Bounds and Approximations for Order Statistics*, Vol. 53, Springer.
5. Gibbons, J.D. & Chakraborti, S. (2021). *Nonparametric Statistical Inference*, Chapman & Hall/CRC Press.
6. Kamps, U. (1995): *A Concept of Generalized Order Statistics*. B.G. Teubner, Stuttgart.

Discipline Specific Elective (DSE) Course 4c: Applied Stochastic Processes

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 4c: Applied Stochastic Processes	4	3	1	0	NIL	Basic knowledge of probability

Course Objectives:

1. To provide understanding of mathematical challenges from a purely applied perspective for a majority of random processes in terms of sequence of event-time pairs.

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

- Make assumptions about the way in which scenarios based on random processes develop.
- Create realistic models for real time situations and to seek solutions to systems-oriented problems.
- Construct approximate theoretical solutions and simulation analysis.
- Theoretical derivations and results based on theorems are exhaustively dealt with.

Unit I (11 Hours)

Discrete Time Markov Chain: Deterministic and Stochastic approach to SIS Epidemic Model, Chain Binomial Greenwood and Reed-Frost Models. Determination of size and Duration. Review of Mathematical expectation, Generating Functions, Central Limit Theorem. Poisson Process: Generator Matrix, Kolmogorov Differential Equations, Stationary Probability Distribution.

Unit II (11 Hours)

General Birth and Death Process, Simple Birth and Simple Death with Immigration, Population Extinction, First Passage Times, Logistic Growth Processes.

Unit III: (13 Hours)

Continuous Time Markov Chain: Deterministic and Stochastic approach to SIR Epidemic Model. Determination of size and Duration. Deterministic and Stochastic approach to Competition Process. Deterministic and Stochastic approach to Predator-Prey Process.

Unit IV: (10 Hours)

Diffusion Process and Stochastic Differential Equations. Some Applications.

Tutorial

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Bailey, N.T.J. (1964). *The Elements of Stochastic Processes*, John Wiley & Sons.
2. Renshaw, Eric (2015). *Stochastic Population Processes: Analysis, Approximations, Simulations*, Oxford University Press.
3. Ross, S. M. (1996). *Stochastic Processes*, John Wiley & Sons.

Suggested Readings:

1. Bhat, B.R. (2000). *Stochastic Models: Analysis and Applications*, New Age International Publishers.
2. Feller, William (1968). *An Introduction to Probability Theory and its Applications*, Vol. I, John Wiley & Sons.
3. Karlin, S. and Taylor, H.M. (1975). *A first course in Stochastic Processes*, Academic Press.
4. Lange, K. (2010). *Applied Probability*, Springer.
5. Prabhu, N.U. (2007). *Stochastic Processes: Basic Theory and its Applications*, World Scientific.
6. Taylor, H.M. and Karlin, S. (1998). *An Introduction to Stochastic Modelling*, Academic Press.

Discipline Specific Elective (DSE) Course 4d: Advanced Statistical Computing and Data Mining

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 4d: Advanced Statistical Computing and Data Mining	**4**	**3**	**0**	**1**	**NIL**	**NIL**

Course Objectives:

- To introduce some advanced statistical computing techniques.
- To extract information, visualization and knowledge about various industries and finance.

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

- Equipped with different theoretical methods and practicable techniques to achieve the objectives.
- Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.
- Evaluate model performance using appropriate statistical and computational metrics.
- Recognize how data mining fits into the broader process of extracting useful knowledge.

Unit I (11 Hours)

Introduction to databases, tasks in building a data mining database, data warehouses, online analytical data processing, Data mining and machine learning, supervised and unsupervised learning.

Unit II (11 Hours)

Similarity and distance measures, Outliers, Minimum spanning tree, squared error clustering, K-means clustering, Hierarchical clustering, Block clustering and two-way clustering: Hartigan's block clustering algorithm, Biclustering, Plaid models for biclustering.

Unit III (11 Hours)

Extensions of regression models, McCullon-Pitts Neuron (Threshold Logic Unit), Rosenblatt's Single layer perceptron, single unit perceptron gradient descent learning algorithm, Multilayer perceptron, feed forward and back propagation learning algorithm, Self organizing maps (SOM) or Kohonen neural network, on-line and batch versions of SOM algorithm.

Unit IV (11 Hours)

Classification trees, node impurity function and entropy function, choosing the best split pruning algorithm for classification trees. Regression trees, terminal node value and splitting strategy, pruning the tree and best pruned subtree. Bagging tree based classifiers and regression tree predictors

Essential Readings:

1. Bishop, C.M. (1995). *Neural Networks for pattern Recognition*, Oxford University Press.
2. Hastie, T., Tibshirani, R. and Friedman, J. (2008). *The Elements of Statistical Learning: Data Mining, Inference and Prediction*, Springer.

Suggested Readings:

1. Duda, R.O., Hart, P.E. and Strok, D.G. (2000). *Pattern Classification*, John Wiley & Sons.
2. Han, J. and Kamber, M. (2000). *Data Mining: Concepts and Techniques*, Morgan
3. Hand, D., Mannila, H. and Smyth, P. (2001). *Principles of Data Mining*, MIT Press.
4. Haykin, S. (1998). *Neural Networks: A Comprehensive Foundation*, Prentice Hall. Kaufmann.
5. McLachlan, G.J. and Krishnan, T. (1997). *The EM Algorithms and Extensions*, John Wiley & Sons.
6. Nakhaeizadeh, G. and Taylor G.C., (1997). *Machine Learning and Statistics*, John Wiley & Sons.
7. Shah, N. and Shah, K. (2023). *Introduction to Data Mining*, Taylor & Francis.
8. Tufféry, S. (2024). *Data Mining and Statistics for Decision Making*, John Wiley & Sons.
9. Witten I.H., Frank, E., Hall, M.A. Hall, Pal, C.J. and Foulds, J. (2025). *Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann Pub*, Morgan Kaufmann.

List of Practicals:

1. Online data processing.
2. Data mining and machine learning.
3. Clustering and unsupervised learning
4. Classification and supervised learning
5. Neural network
6. Regression trees

Discipline Specific Elective (DSE) Course 4e: Forestry and Environmental Statistics

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 4e: Forestry and Environmental Statistics	**4**	**3**	**1**	**0**	**NIL**	**NIL**

Course Objectives:

- To provide students with understanding of forestry and environmental statistics.
- Explore national and state data sources, data collection mechanisms, experimental design, and statistical analysis tools.
- Emphasizes the role of institutions, forest resource assessment, biodiversity evaluation, and the economic contributions of the forestry sector, including trade and ecosystem services.

Course Learning Outcomes: Upon successful completion of this course, students will be able to:

- Describe the structure of the forestry sector of India (State Forest Departments (SFDs) and State Forest Development Corporations and forest based industry) in generating forestry statistics.
- Identify key national and state-level forestry and environmental data sources along with their major publications.
- Explain methodologies for tree growth measurement, forest classification, and data collection mechanisms including working plans and afforestation statistics.
- Apply knowledge of vegetation sampling techniques and biodiversity assessment, including sampling unit design and biodiversity indices.
- Understand yield estimation techniques for forest resources using non-destructive methods and volume equations.
- Analyze statistics related to forest land diversion, production of timber and non-timber forest products, and their relation to other land parameters.
- Evaluate the economic contribution of forestry to India's GDP, including the valuation of tangible and intangible ecosystem services.
- Examine trends and data related to international trade in the forestry and environmental sector.

Unit I (11 Hours)

Important parameters to assess the health of forests (growth parameters of trees, soil characteristics, regeneration). Methodologies to assess regeneration, modeling growth of trees forest cover. Assessing recorded forest area; reserved and protected forest cover. Forestry Statistics related to State Forest Departments (SFDs) and Forest Development Corporations. Statistical applications in preparation of working plans of SFDs. Sample surveys to assess afforestation programmes. Preparation of volume and yield tables.

Unit II (11 Hours)

National Forest Inventory. Volume and yield allometric equations, yield estimation of trees using non-destructive methods (Newton, Huber, Smalian methods). Vegetation sampling: sampling units (point frame transect and quadrat); size and shape of sampling unit. Sample size calculations for biodiversity assessments; various biodiversity indices and their roles. Species Area Curves.

Unit III (11 Hours)

Estimation of biomass and carbon stocks, Concept of default values. UNFCCC methodologies for carbon assessment and REDD plus activities. Statistical methods for the estimation of parameters pertaining to the scopes of Green House Gas (GHG) Emissions.

Unit IV (12 Hours)

Statistics available on diversion of forest land for non-forestry purposes, estimating production of timber, non-timber forest products and bamboo. Relationship building with the other parameters like geographical area, forest area etc. Gross Domestic Products on Forestry Sector and its estimation. Forestry and Logging sector in National Industrial Classification (NIC). Concept of Green GDP and its assessment. Analyzing international trade in forest products, the ITC HS system and the data available with the DGCIS. Forest based industries.

Tutorial:

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. *Forest Sector Report India (2019).* Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change, Government of India.

2. *Forest Statistics India (2021).* Indian Council of Forestry Research and Education, Ministry of Environment, Forest and Climate Change, Government of India.

3. *India State of Forest Reports* (2019-25). Forest Survey of India, Ministry of Environment, Forest & Climate Change, Government of India, Dehradun.

Suggested Readings

1. Chandra, G., Nautiyal, R. and Chandra, H. (Eds.) (2020). Statistical Methods and Applications in Forestry and Environmental Sciences. Forum for Interdisciplinary Mathematics. Springer.

2. Directorate General of Commercial Intelligence and Statistics. *DGCI&S - Government of India*. Available at: https://www.dgciskol.gov.in.

3. Gelfand, A. E. (2019). Handbook of Environmental and Ecological Statistics. United States: CRC Press.

4. Kant, P. and Nautiyal, R. (2021). India Timber Supply and Demand 2010–2030, International Tropical Timber Organization, Japan.

5. Official reports of various Ministries, Government of India and State Forest Departments.

Discipline-Specific Elective (DSE) Course- 4f: Statistical Decision Theory

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
DSE 4f: Statistical Decision Theory	**4**	**3**	**1**	**0**	**NIL**	**Basic knowledge of Bayesian Inference**

Course Objectives:

- To provide a set of powerful decision-making methods that will help the students to gain critical awareness.
- To develop ability in choosing and using these methods in order to solve various decision-making problems.

Course Learning Outcomes: After successful completion of this course, the students will be able to:

- Understand the concept of space of randomized decisions, behavioural and optimal decision rules.
- Understand geometric interpretation and applications of Bayes decision rules.
- Discernment and comprehension of notions of admissibility and completeness.
- To handle group decision making in the presence of qualitative variables.
- Formulate solutions of decisions under uncertainty and risks

Unit I (11 Hours)

Decision problem and 2-person game, utility theory, expected loss, decision rules (non-randomized and randomized), decision principles, optimal decision rule.

Unit II (12 Hours)

Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules. Supporting and separating hyperplane theorems, minimax theorem of finite parameter space, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Unit III (11 Hours)

Invariant decision rules – location parameter problems, invariance and minimaxity, admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations.

Unit IV (11 Hours)

Sufficient statistics essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

Tutorial

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Berger, J.O. (2013). *Statistical Decision Theory and Bayesian Analysis*, Springer.
2. Ferguson, T.S. (2014). *Mathematical Statistics: A Decision Theoretic Approach*, Academic Press.
3. Robert, C.P. (2007). *The Bayesian Choice: A Decision Theoretic Motivation*, Springer.

Suggested Readings:

1. Berger, J.O., Bernardo, J.M. and Sun, D. (2023). *Objective Bayesian Inference*, World Scientific.
2. Bernando, J.M. and Smith, A.F.M. (2000). *Bayesian Theory*, John Wiley & Sons.
3. Rao, C.R. (2002). *Linear Statistical Inference and its Applications*, Wiley Eastern.
4. Rohatgi, V.K., and Saleh, A.K.Md.E. (2015). *An Introduction to Probability and Mathematical Statistics*, Wiley Eastern.

Discipline Specific Elective (DSE) Course 4g: Survival Analysis

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research
Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
DSE 4g: Survival Analysis	4	3	0	1	NIL	NIL

Course Objectives:

- To introduce the theoretical and inferential framework for data in survival analysis.
- To develop understanding of special features of survival data structures including censoring, frailty, competing risks, and multistate model.

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

- Understand the concepts of survival data, including survival and hazard functions, censoring, and estimation of lifetime distributions.
- Perform regression modeling in survival data using Cox proportional hazards and frailty models.
- Apply survival models that handle complex structure of survival data such as censoring and masked data.
- Apply and interpret some parametric and semi-parametric survival models.
- Analyze competing risks and masked cause-of-failure data to address real-life problems.
- Model multistate process in survival analysis.
- Perform model assessment and diagnostics for survival models.

Unit I (11 Hours)

Overview of survival function, hazard functions, various forms of censoring, and parametric estimation of lifetime distributions, Probability plotting, non-parametric hypothesis testing: Gehan and Mantel Hanzel statistics, stratified log-rank test.

Unit II (12 Hours)

Cox Proportional hazard: Time-dependent covariates and stratified Cox model, Frailty models: Likelihood formulation for Gamma frailty under Exponential and Weibull baselines. Parameter estimation, and comparison of frailty models with Cox models.

Unit III (11 Hours)

Competing risks model for masked data, Likelihood formulation for exponential, and Weibull distributed risks, Issue of identifiability, Parameter estimation, Model selection, Multiple decrement life table under competing risks.

Unit IV (11 Hours)

Introduction to multistate models: concept of states and transitions, parametric modeling of transition intensities (Exponential, Weibull).

Essential Readings:

1. Barlow, R. E., and Proschan, F. (1985). *Statistical Theory of Reliability and Life Testing*, Holt, Rinehart and Winston.
2. Beyersmann, J., Allignol, A., and Schumacher, M. (2011). *Competing Risks and Multistate Models with R*, Springer.
3. Deshpande, J. V., and Purohit, S. G. (2015). *Lifetime Data: Statistical Models and Methods*, World Scientific Publishing Company.
4. Lawless, J. F. (1982). *Statistical Models and Methods of Lifetime Data*, John Wiley & Sons.

Suggested Readings:

1. Bain, L. J., and Engelhardt, M. (1991). *Statistical Analysis of Reliability and Life Testing Models*, Marcel Dekker.
2. Hanagal, D. D. (2019). *Modeling Survival Data Using Frailty Models*, Chapman & Hall/CRC.
3. Kalbfleisch, J. D., and Prentice, R. L. (2002). *The Statistical Analysis of Failure Time Data*, John Wiley & Sons.
4. Lee, E. T., and Wang, J. W. (2003). *Statistical Methods for Survival Data Analysis*, John Wiley & Sons.
5. Nelson, W. (1982). *Applied Life Data Analysis*, John Wiley & Sons.

List of Practicals:

1. Estimation of survival and hazard functions under different lifetime distributions and censoring schemes.
2. Probability plotting for exponential, Weibull, and log-normal distribution for complete and censored data.
3. Non-Parametric hypothesis testing using Gehan's test and Mantel–Haenszel.
4. Analyze survival data with stratified groups and perform stratified log-rank test and interpret results.

5. Fit a Cox proportional hazards model with time-varying covariates and compare results with a simple Cox model.
6. Fit frailty models under exponential and Weibull baselines and compare it with Cox models.
7. Perform analysis of competing risks with missing cause of failure.
8. Construct a multiple decrement life table using competing risks data.
9. Simulate simple 3-state data and summarize transition patterns.
10. Fit a parametric multistate model, estimate the parameters, and interpret the estimated transition probabilities.

Generic Elective (GE) Courses

Generic Elective (GE) Course 4a: Inferential Techniques

Structure 1: PG Curricular Structure with only Course Work
Structure 2: PG Curricular Structure with Course Work + Research

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (45 Hours)	Tutorial (15 Hours)	Practical (00 Hours)		
GE 4a: Inferential Techniques	4	3	1	0	NIL	NIL

Course Objectives:

- To arrive at an estimator that exhibits optimality.
- To introduce the basic elements of statistical inference.
- To provide a theory of testing and closely related theory of point estimation and confidence sets, together with their applications.

Course Learning Outcomes: On successful completion of this course, the students will be able to:

- Describe the methods of estimation and hypothesis testing.
- Understand the various estimation and testing procedures to deal with real life problems.
- Understand the concept of critical regions, likelihood ratio test with its asymptotic distribution.
- Learn about the Fisher Information, lower bounds to variance of estimators, MVUE.

Unit I (11 Hours)

Concept of estimation theory, estimate and estimator, properties of good estimator: unbiasedness, efficiency consistency and sufficiency. C.R. inequality and minimum variance unbiased estimator (MVUE). Examples based on discrete and continuous distributions.

Unit II (11 Hours)

Methods of estimation: Method of moments, method of maximum likelihood (statement and properties) and method of minimum chi-square. Interval estimation: Concepts of confidence interval.

Unit III (12 Hours)

Testing of Hypotheses: Statistical hypotheses, null and alternative hypotheses, simple and composite hypotheses, critical region, error of type I and type II, size and power of a test and p-value. Test of significance based on normal distribution (tests for single proportion, difference of two proportions, single mean and difference of two means).

Unit IV (11 Hours)

Test for single mean, difference of two means, paired t-test, test for sample correlation coefficient based on t-distribution Tests based on Chi-square distribution and F-distribution.

Tutorial

Tutorial sessions will include at least one activity such as group discussion/presentation/ problem solving exercise based on the material covered in the lectures along with scholastic work related to the conceptual understanding of the subject.

Essential Readings:

1. Casella, G. and Berger, R.L. (2013). *Statistical Inference*, Cengage Learning.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B (2005): *An Outline of Statistical Theory-Vol. II*, World Press Private Limited, Kolkata.
3. Hogg, R.V., McKean, J. W. and Craig A.T. (2019). *Introduction to Mathematical Statistics*, Pearson.
4. Kale, B.K. (2005). *Parametric Inference*, Narosa Publishing House.
5. Mukhopadhyay, P. (2016). *Mathematical Statistics*, New Central Book Agency.

Suggested Readings:

1. Kumar, U.D. (2017): *Business Analytics: The Science of Data-Driven Decision Making*, John Wiley & Sons.
2. Mood, A., Graybill, F. and Boes, B. (2017). *Introduction to the Theory of Statistics*, Mc-Graw Hill.
3. Rohatgi V.K. and Saleh, A.K.Md.E. (2015): *An Introduction to Probability and Statistics*, John Wiley & Sons.

Skill Based/Specialized Laboratory (SB) Courses

Skilled Based/Specialized Laboratory (SB) Course 4a: Data Analysis using SPSS

Structure 1: PG Curricular Structure with only Course Work

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (00 Hours)	Tutorial (00 Hours)	Practical (60 Hours)		
SB 4a: Data Analysis using SPSS	**2**	**0**	**0**	**2**	**NIL**	**NIL**

Course Objectives:

- To familiarize students with data analysis using a statistical software package SPSS.
- To provide skills for research analysis and increase employability.
- To lay a foundation for advance data analysis work and higher education.

Course Learning Outcomes:

- Understand basic functions of SPSS for managing variables and generate descriptive statistics to describe the data and analyze data through graphs and charts.
- Test differences in sample means.
- Identify relationships between variables and develop models for predicting dependent variables on the basis of independent variables.
- Understand data structures and identify clusters in data.
- Identify principal components that are relevant from a host of variables.

Unit I (15 Hours)

Bivariate Analysis: Crosstabulation, Chi-square test of association, Bivariate Correlation (Pearson and Spearman), Simple Scatterplots. Descriptive Statistics Procedures: Frequencies, Descriptive, Explore. Graphs: Creating and editing graphs and charts. Hypothesis Testing: t-tests: One sample test, independent samples and paired samples t-test; ANOVA - One way analysis of variance, Two way analysis of variance, Parametric and Non-Parametric test: Run test, Wilcoxon signed-rank test, Kolmogorov–Smirnov test, Mann-Whitney U test, Kruskal-Wallis test, Friedman.

Unit II (15 Hours)

Understanding the principles of randomization, replication, and blocking; Application of One-way and Two-way classification models using SPSS; Analysis of data from Completely Randomized Design (CRD), Randomized Block Design (RBD), and Latin Square Design (LSD) through General Linear Model (GLM) procedures; Linear Regression: Simple Linear Regression, Multiple regression analysis,

Unit III (15 Hours)

Logistic Regression model, Lack-of-Fit tests in logistic regression. Time Series Analysis: Understanding components of a time series (trend, seasonal, cyclical, irregular); Creating and editing time series plots; Conducting trend analysis using SPSS; Smoothing techniques – Moving Average and Exponential Smoothing methods; Model identification and forecasting using SPSS; Auto-correlation and partial autocorrelation plots.

Unit IV (15 Hours)

Hierarchical Cluster analysis and K-Means Cluster Analysis, Factor analysis, Principal Components Analysis, Discriminant Analysis.

Essential Reading:

1. George. D and Paul Malley (2010): *SPSS for Windows Step by Step A Simple Guide and Reference.*
2. Lawrence, S., Meyers, L.S., Gamst, G.C. and Guarino, A.J. (2013): *Performing Data Analysis using IBM SPSS*, John Wiley & Sons.

Suggested Readings:

1. Pandya, K., Bulsari, S. and Sinha, S. (2011): *SPSS in Simple Steps*, Dreamtech Press.

Research Methods/Tools/ Writing (RTW) Course 4a: Techniques of Research Writing

Structure 3: PG Curricular Structure with Research only

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Prerequisite of the course (if any)
		Lecture (15 Hours)	Tutorial (00 Hours)	Practical (30 Hours)		
RTW 4a: Techniques of Research Writing	**2**	**1**	**0**	**1**	**NIL**	**NIL**

Course Objectives:

- To familiarise students with the structure and components of research papers in both theoretical and empirical statistical studies.
- To develop proficiency in using professional document preparation tools such as LaTeX, Overleaf, and Beamer for writing and presentation.

Course Learning Outcomes: After successful completion of this course, the students will be able to:

- Explain and distinguish the structure of theoretical and empirical research papers.
- Create and format professional-quality manuscripts using MS Word, LaTeX, Overleaf, and PowerPoint.
- Apply reference management tools like Mendeley and BibTeX.
- Use SQL for basic data organisation and management, ensuring structured, reliable, and reproducible data handling in research.
- Evaluate academic integrity by identifying plagiarism, fabrication, and falsification.

Unit I (7 hours)

Structure of a generic research paper in theoretical and empirical studies, respectively.

Unit II (8 hours)

Article writing using LaTeX, Overleaf, and Beamer for content presentation. MS Word, PowerPoint.

Unit III (7 hours)

Use of Mendeley and BibTeX for referencing. Data management using SQL.

Unit IV (8 hours)

Plagiarism, Fabrication and Falsification: Journal and research ranking matrices.

Essential readings:

1. Creswell, J.W. and Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, SAGE Publications.
2. Lamport, L. (1999). *LATEX: A Document Preparation System*, Addison Wesley.
3. Lipson, C. (2018). *Doing Honest Work in College: How to Prepare Citations, Avoid Plagiarism, and Achieve Real Academic Success*, University of Chicago Press.

Suggested Readings:

1. Booth, W.C., Colomb, G.G. and Williams, J.M. (2016). *The Craft of Research*, University of Chicago Press.
2. Coronel, C. and Morris, S. (2019). *Database Systems: Design, Implementation, and Management*, Cengage Learning.
3. Kopka, H. and Daly, P.W. (2003). *A Guide to LaTeX: Document Preparation for Beginners and Advanced Users*, Addison Wesley.
4. Van Emden, J. and Becker, L. (2016). *Presentation Skills for Students*, Palgrave Macmillan.

List of Practicals:

1. Preparing academic documents and presentations using LaTeX/Overleaf, Beamer, MS Word, and PowerPoint.
2. Managing references using Mendeley and BibTeX.
3. Performing basic data management tasks and queries using SQL.
4. Understanding and identifying issues related to plagiarism, fabrication, and falsification in research.
5. Exploring journal and researcher ranking metrics.

DEPARTMENT OF STATISTICS
FACULTY OF MATHEMATICAL SCIENCES
UNIVERSITY OF DELHI, DELHI - 110007

M.A./M.Sc. (Statistics)

Curricular Structures of Second year of Two-year PG Programme (3+2)

OR

One year PG Programme after completion of Four-Year UG Programme (4+1)

Structure 1 (Level 6.5): PG Curricular Structure with only Course work

Semester	Discipline-Specific Core (DSC) Courses	Discipline-Specific Elective (DSE) Courses	Generic Elective (GE) Courses	Skill Based (SB)/ Specialized Laboratory Courses
III	DSC 3a Advanced Statistical Inference DSC 3b Multivariate Analysis	DSE 3a Advanced Theory of Experimental Designs DSE 3b Operational Research DSE 3c Actuarial Statistics DSE 3d Stochastic Models DSE 3e Statistical Quality Management DSE 3f Advanced Survey Sampling DSE 3g Bayesian Inference	GE 3a Essentials of Survey Sampling and Experimental Designs GE 3b Applied Multivariate Statistics	SB 3a Data Analysis Using R
IV	DSC 4a Generalized Linear Models DSC 4b Econometrics	DSE 4a Statistics in Finance DSE 4b Order Statistics DSE 4c Applied Stochastic Processes DSE 4d Advanced Statistical Computing and Data Mining DSE 4e Forestry and Environmental Statistics DSE 4f Statistical Decision Theory DSE 4g Survival Analysis	GE 4a Inferential Techniques	SB 4a Data Analysis Using SPSS

Structure 2 (Level 6.5): PG Curricular Structure with only Course work +Research

Semester	Discipline-Specific Core (DSC) Courses	Discipline-Specific Elective (DSE) Courses	Generic Elective (GE) Courses	Dissertation/Academic project/Entrepreneurship (DAE)
III	DSC 3a Advanced Statistical Inference DSC 3b Multivariate Analysis	DSE 3a Advanced Theory of Experimental Designs DSE 3b Operational Research DSE 3c Actuarial Statistics DSE 3d Stochastic Models DSE 3e Statistical Quality Management DSE 3f Advanced Survey Sampling DSE 3g Bayesian Inference	GE 3a Essentials of Survey Sampling and Experimental Design GE 3b Applied Multivariate Statistics	DAE 3a Dissertation DAE 3b Academic project DAE 3c Entrepreneurship
IV	DSC 4a Generalized Linear Models DSC 4b Econometrics	DSE 4a Statistics in Finance DSE 4b Order Statistics DSE 4c Applied Stochastic Processes	GE 4a Inferential Techniques	DAE 4a Dissertation DAE 4b Academic project DAE 4c Entrepreneurship

		DSE 4d Advanced Statistical Computing and Data Mining DSE 4e Forestry and Environmental Statistics DSE 4f Statistical Decision Theory DSE 4g Survival Analysis		

Structure 3 (Level 6.5): PG Curricular Structure with Research only

Semester	Discipline-Specific Core (DSC) Courses	Discipline-Specific Elective (DSE) Courses	Research Methods/Tools/Writing (RTW) Courses	One intensive problem-based research
III	DSC 3c Bayesian Inference	DSE 3a Advanced Theory of Experimental Designs DSE 3b Operational Research DSE 3c Actuarial Statistics DSE 3d Stochastic Models DSE 3e Statistical Quality Management DSE 3f Advanced Survey Sampling	RTW 3a Advanced Research Methodology RTW 3b Tools for Research	To be decided
IV	Nil	DSE 4a Statistics in Finance DSE 4b Order Statistics DSE 4c Applied Stochastic Processes DSE 4d Advanced Statistical Computing and Data Mining DSE 4e Forestry and Environmental Statistics DSE 4f Statistical Decision Theory DSE 4g Survival Analysis	RTW 4a Techniques of Research Writing	