Curriculum and Syllabus of

M.Sc. in Statistics

with specialization in

Industrial Statistics/Biostatistics/Economic Statistics

(July 2026 onwards)

Programme Educational Objectives

PEO 1: To introduce students to the meaning, concepts and scope of the basic Statistical and Mathematical tools applicable for decision-making.

PEO 2: To familiarize students with the different tools and techniques used for collecting, handling, and managing and interpreting data.

PEO 3: To make the students acquainted with methods of data analysis and interpretation with focus on statistical tools.

PEO 4: To enable students to perform data visualization and analysis using modern statistical software packages such as Python, SPSS, R etc.

PEO 5: To enable students to get familiarized with different techniques of data driven statistical inference.

PEO 6: To encourage students towards various types of research and methodologies of conducting research.

Programme Outcomes

PO1: Understanding the basic Statistical and Mathematical tools applicable for decision-making.

PO2: Designing questionnaires or perform other survey methods to collect data from primary sources supporting independent research initiatives.

PO3: Applying advanced quantitative and statistical tools envisaged in the course in collecting, analyzing and interpreting data.

PO4: Using statistical software packages in the process of generation of graphs, charts, and other forms of data visualization, data analysis and data interpretation.

PO5: Enabling to independently solve real life problems.

PO6: Assisting the policy makers in framing plans on different aspects of national development.

PO7: Understanding and predicting the movement different data series related to industry, business and healthcare.

Curriculum for M.Sc. Statistics

M.Sc. in Statistics with specialization in

1. **Industrial Statistics (IS)**
2. **Biostatistics (BS)**
3. **Economic Statistics (ES)**

Total Marks: 2000

Total Credit: 80

Semester wise details

Semester – I								
Number of Papers: 5								
Course Code	**Course Title**	**Course Type**		**Credits in each course**				**Total Marks**
			Theory	**Practical**	**Tutorial**	**Internship/Project or Dissertation**	**Credits**	
MSTR110T	Stochastic Processes	Core	4	0	0	0	4	100
MSTR120C	Applied Multivariate Analysis	Core	3	1	0	0	4	100
MSTR130C	Linear Models & Regression Analysis	Core	3	1	0	0	4	100
MSTR140C	Discrete Data Analysis	Core	3	1	0	0	4	100
MSTR150P	R & Python	Core	0	4	0	0	4	100
Total			**13**	**7**	**0**	**0**	**20**	**500**

Semester – II								
Number of Papers: 5								
Course Code	**Course Title**	**Course Type**		**Credits in each course**				**Total Marks**
			Theory	**Practical**	**Tutorial**	**Internship/Project or Dissertation**	**Credits**	
MSTR210T	Probability Theory	Core	4	0	0	0	4	100
MSTR220C	Statistical Inference	Core	3	1	0	0	4	100
MSTR230C	Bayesian Inference	Core	3	1	0	0	4	100

MSTR240C	Sample Survey and Design of Experiments	Core	3	1	0	0	4	100
MSTR250 C	Resampling Techniques & Time Series Analysis	Core	3	1	0	0	4	100
Total			**16**	**4**	**0**	**0**	**20**	**500**

Semester – III								
Number of Papers: 5								
Course Code	**Course Title**	**Course Type**		**Credits in each course**				
			Theory	**Practical**	**Tutorial**	**Internship/ Project or Dissertation**	**Credits**	**Total Marks**
MSTR310C	Statistical Learning	Core	3	1	0	0	4	100
MSTR320J	Introduction to Research and Dissertation	Project	0	0	0	4	4	100
Elective (Select any one of the following courses)								
MSTR331C	Optimization Techniques	Elective	3	1	0	0	4	100
MSTR341C	Advanced Statistical Inference	Elective	3	1	0	0	4	100
MSTR351C	Demography & Development Statistics	Elective	3	1	0	0	4	100
Select any one of the following specialization buckets								
Specialization Bucket: **IS**								
MSTR362C	Operations Research	Elective	3	1	0	0	4	100
MSTR373C	Reliability Analysis	Elective	3	1	0	0	4	100
Specialization Bucket: **BS**								
MSTR382C	Survival Analysis	Elective	3	1	0	0	4	100
MSTR393C	Clinical Trials	Elective	3	1	0	0	4	100
Specialization Bucket: **ES**								

MSTR3102C	Actuarial Statistics	Elective	3	1	0	0	4	100
MSTR3113C	Econometrics	Elective	3	1	0	0	4	100
Total			**12**	**4**	**0**	**4**	**20**	**500**

Semester - IV								
Number of Papers: 3								
Course Code	**Course Title**	**Course Type**	**Credits in each course**				**Credits**	**Total Marks**
			Theory	**Practical**	**Tutorial**	**Internship/ Project or Dissertation**		
MSTR410J	Project based Internship	Internship	0	0	0	4	4	100
MSTR420J	Dissertation	Project	0	0	0	12	12	300
	Students who chose IS/BS/ES bucket in sem. III, should choose a paper from the corresponding bucket							
	Specialization Bucket: **IS** (Select any one of the following courses)							
MSTR434C	Statistical Quality Management	Elective	3	1	0	0	4	100
MSTR444C	Supply Chain Management	Elective	3	1	0	0	4	100
	Specialization Bucket: **BS** (Select any one of the following courses)							
MSTR454C	Epidemiology	Elective	3	1	0	0	4	100
MSTR464C	Statistical Genetics	Elective	3	1	0	0	4	100
	Specialization Bucket: **ES** (Select any one of the following courses)							
MSTR474C	Advanced Time Series	Elective	3	1	0	0	4	100
MSTR484C	Financial Econometrics	Elective	3	1	0	0	4	100
Total			**3**	**1**	**0**	**16**	**20**	**500**

Notes:

1.Elective courses and specialization modules shall be offered in accordance with university norms and the discretion of the department.

2. The marks distribution for the CIA and End Semester Examination shall be as per the university norms and the discretion of the Controller of Examinations.

SEMESTER: I

Stochastic Processes

Credit: 4 (T) + 0 (P)
Paper Code: MSTR110T

Course Outcomes (CO):

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

CO1: Enable students to understand foundational concepts of stochastic processes.

CO2: Familiarize the students with discrete-time Markov chain models.

CO3: Gain deeper understanding of Poisson and renewal process models.

CO4: Make the students acquainted with long-run and asymptotic properties of stochastic systems.

CO5: Develop probabilistic reasoning using conditional expectation and martingales.

Module No.	Module Name	Chapter Topic	CO
I	Introduction to stochastic processes	Definition and examples of stochastic processes Classification: discrete/continuous time, discrete/continuous state space Counting processes – definition and basic properties. Introduction to discrete parameter Martingales (definition, simple properties, examples) Random walk	CO1
II	Discrete-time Markov Chains	Markov property and time-homogeneity, Transition probability matrix One-step and n-step transition probabilities Chapman–Kolmogorov equations Classification of states: communication, recurrence, transience Periodicity and ergodicity Stationary distributions and limiting behaviour Reversibility Introduction to elementary MCMC methods Applications: Birth–death chains and simple branching processes	CO2
III	Poisson Processes	Definition and postulates of Poisson Processes Inter-arrival time distribution Basic properties Non-homogeneous Poisson process (definition and properties) Compound Poisson process (basic idea and applications)	CO3, CO5

IV	Renewal Theory	Renewal process and renewal function Elementary Renewal Theorem Inspection paradox Asymptotic behaviour of renewal processes (statement and interpretation)	CO4, CO5

References:

1. Karlin, S., & Taylor, H. M. (1975). *A first course in stochastic processes* (2nd ed.). Academic Press.
2. Medhi, J. (1994). *Stochastic processes* (2nd ed.). Wiley Eastern Limited.
3. Cox, D. R. (1962). *Renewal theory*. Methuen.
4. Ross, S. M. (2014). *Introduction to probability models* (11th ed.). Academic Press.
5. Basu, A. K. (2005). *Introduction to stochastic processes*. Narosa Publishing House.
6. Hoel, P. G., Port, S. C., & Stone, C. J. (1972). *Introduction to stochastic processes*. Waveland Press.
7. Bhattacharya, R. N., & Waymire, E. C. (1990). *Stochastic processes with applications*. Wiley.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	M				H
CO2		H		L		L	M
CO3	H				H		
CO4	H	M		L			M
CO5	H	H	M		H	L	H
AVG	2.4	2	0.8	0.4	1.2	0.4	2

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Applied Multivariate Analysis

Credit: 3 (T) + 1 (P)
Paper Code: MSTR120C

Course Outcomes (CO):

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

CO1: Apply clustering techniques to group multivariate data and determine the optimal number of clusters.

CO2: Develop an understanding of discriminant functions for classification between two populations and evaluate misclassification errors.

CO3: Apply the Fisher's method to classify observations among multiple populations.

CO4: Apply Principal Component Analysis and Factor Analysis for dimensionality reduction.

CO5: Analyze multivariate data using multivariate regression, MANOVA, and MANCOVA.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Clustering of Observations	Hierarchical clustering for continuous and categorical data - different choices of proximity measures, Agglomerative and Divisive algorithms, K-means clustering, optimum choice of the number of clusters, Silhouette Index.	**CO1**
II	Classification and Discriminant procedures	Discrimination between two known populations – Likelihood Ratio procedures. Discrimination between two multivariate normal populations. Sample discriminant function. Likelihood ratio rule. Tests associated with discriminant function, Probabilities of misclassification and their estimation.	**CO2**
III	Classification of several populations	Discrimination among several populations. Fisher's method for discriminating among several populations.	**CO3**
IV	Principal Component Analysis	Population and sample principal components and their uses. Biplot, Large sample inferences.	**CO4**
V	Factor Analysis	The orthogonal factor model, Estimation of factor loading, Factor rotation, Estimation of Factor scores, Interpretation.	**CO4**
VI	Multivariate Linear Models	Multivariate Regression Model, MANOVA and MANCOVA	**CO5**

References:

1. Anderson, T. W. (1984). *An introduction to multivariate statistical analysis* (2nd ed.). John Wiley & Sons.
2. Giri, N. C. (2004). *Multivariate statistical inference*. Marcel Dekker.
3. Johnson, R. A., & Wichern, D. W. (2007). *Applied multivariate statistical analysis* (6th ed.). Pearson Prentice Hall.
4. Morrison, D. F. (2005). *Multivariate statistical methods* (4th ed.). Thomson Brooks/Cole.
5. Seber, G. A. F. (2004). *Multivariate observations*. John Wiley & Sons.
6. Sharma, S. C. (1996). *Applied multivariate techniques*. John Wiley & Sons.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	M				H

CO2		H		L		L	M
CO3	H				H		
CO4	H	M		L			M
CO5	H	H	M		H	L	H
AVG	2.4	2	0.8	0.4	1.2	0.4	2

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Linear Models & Regression Analysis

Credit: 3 (T) + 1 (P) **Paper Code: MSTR130C**

Course Outcomes (CO):

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

CO1: Formulate and analyze the General Linear Model and derive BLUE under classical assumptions.

CO2: Apply ANOVA, ANCOVA, and variance component models in experimental data analysis.

CO3: Perform model selection and diagnose multicollinearity and functional form issues.

CO4: Conduct model diagnostics and apply appropriate remedial measures.

CO5: Critically interpret regression output for research applications.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Gauss Markov Model	Estimable function, error function, BLUE, Gauss Markov theorem. Correlated set-up, least squares estimate with restriction on parameters	**CO1**
II	General Linear Hypothesis	Linear Sets, General linear hypothesis – related sampling distribution, Multiple comparison techniques due to Scheffe and Tukey.	**CO1**
III	Analysis of Variance and Covariance	Balanced classification, Fixed Effects Model, Random Effects Model and Mixed Effects Model; Inference on Variance components. Analysis of covariance.	**CO2**
IV	Departures from Gauss-Markov set-up	Heteroscedasticity – concept, consequences, detection, remedial measures. Autocorrelation – concept, consequences, detection, remedial measures.	**CO3, CO5**
V	Multicollinearity	Concept, consequences, detection, remedial measures.	**CO4, CO5**

VI	Normality	Q-Q plot, Normal Probability plot, Shapiro-Wilks Test	**CO4, CO5**

References:

1. Chatterjee, S., & Hadi, A. S. (2012). *Regression analysis by example* (5th ed.). John Wiley & Sons.
2. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). *Introduction to linear regression analysis* (5th ed.). John Wiley & Sons.
3. Ryan, T. P. (2008). *Modern regression methods* (2nd ed.). John Wiley & Sons.
4. Draper, N. R., & Smith, H. (1998). *Applied regression analysis* (3rd ed.). John Wiley & Sons.
5. Belsley, D. A., Kuh, E., & Welsch, R. E. (1980). *Regression diagnostics: Identifying influential data and sources of collinearity*. John Wiley & Sons.
6. Johnston, J., & DiNardo, J. (1997). *Econometric methods* (4th ed.). McGraw-Hill.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	**PO5**	PO6	**PO7**
CO1	H	L	H	M	M	L	M
CO2	H	M	H	H	H	M	M
CO3	M	L	H	H	H	M	M
CO4	M	L	H	H	H	M	M
CO5	M	M	H	M	H	H	H
Average	2.4	1.4	3.0	2.6	2.8	2.0	2.4

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Discrete Data Analysis

Credit: 3 (T) + 1 (P)
Paper Code: MSTR140C

Course Outcomes (CO):

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

CO1: Remember and categorize measures of association for nominal and ordinal data and identify their appropriate applications.
CO2: Understand Explain the components of GLMs, interpret maximum likelihood estimates, and describe the role of deviance in model assessment.
CO3: Apply Construct GLMs for binary, count and polytomous data, and implement them using statistical software.
CO4: Analyze Diagnose overdispersion in non-normal data, compare quasi-likelihood and alternative models and justify solutions.
CO5: Evaluate Critically assess extensions of GLMs and select the best-fitting

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Measures of Association	Measures of association for classified nominal and ordinal categorical data.	C01
II	Generalized Linear Models	Introduction, Components of a GLM, Maximum Likelihood estimation, Deviance.	CO2
III	Categorical and Count Data Regression	Binary data and Count data: ungrouped and grouped. Models with constant coefficient of variation. Polytomous data.	CO3
IV	Overdispersion	Overdispersion and fitting by quasi-likelihood.	CO4
V	Extensions to other models	Extensions of GLMs: Zero inflated Poisson models, Joint modelling of mean and variance, Concept of Generalized Linear Mixed Models (GLMM).	CO5

References:

1. Agresti, A. (2010). *Analysis of ordinal categorical data* (2nd ed.). John Wiley & Sons.
2. Agresti, A. (2013). *Categorical data analysis* (3rd ed.). John Wiley & Sons.
3. McCullagh, P., & Nelder, J. A. (1989). *Generalized linear models* (2nd ed.). Chapman & Hall.
4. McCulloch, C. E., & Searle, S. R. (2001). *Generalized, linear, and mixed models* (2nd ed.). John Wiley & Sons.
5. Hastie, T., & Tibshirani, R. (1990). *Generalized additive models*. Chapman & Hall.
6. Györfi, L., Kohler, M., Krzyżak, A., & Walk, H. (2002). *A distribution-free theory of nonparametric regression*. Springer.
7. Pagan, A., & Ullah, A. (1999). *Nonparametric econometrics*. Cambridge University Press.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**H**	**M**	**M**				**H**
CO2		**H**		**L**		**L**	**M**
CO3	**H**				**H**		
CO4	**H**	**M**		**L**			**M**
CO5	**H**	**H**	**M**		**H**	**L**	**H**
AVG	**2.4**	**2**	**0.8**	**0.4**	**1.2**	**0.4**	**2**

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R & Python

Credit: 0 (T) + 4 (P)
Paper Code: MSTR150P

Course Outcome (CO):

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

CO1: Explain the programming environments, data structures, and core functionalities of R and Python for statistical computing.
CO2: Use R tools for data handling, visualization, descriptive statistics, regression analysis, and matrix computations.
CO3: Apply Python libraries to perform numerical computation, data visualization, and basic statistical analysis.
CO4: Analyse statistical problems using simulation techniques, probability models, hypothesis testing, and inference methods in R and Python.
CO5: Design and implement end-to-end data analysis workflows using R and Python, including data cleaning, modelling, and result interpretation.

Module No.	Module Name	Chapter Topic	CO
I	Introduction to R and Statistical Data Analysis	Introduction to the R environment and commonly used packages. Basic data types and data structures in R. Handling data using vectors, matrices, data frames, and lists. Descriptive statistics. Univariate and Multivariate data analysis. Basic programming in R: conditional statements, loops, and user-defined functions. Probability distributions in R and random number generation. Use of set.seed().	**CO1, CO2, CO5**
II	Programming & Simulation in R	Introduction to simulation and Monte Carlo methods. Computation of bias and mean-squared error of estimators using simulation. Estimation of coverage probability, empirical level, and power of tests. Importing and exporting data files in R and simple applications based on statistical problems.	**CO2, CO4, CO5**

III	Python Basics and Programming Fundamentals	Introduction to Python environment, Numbers, variables, data types, Strings, lists, tuples, Comparisons and logical operators, Control flow: if–else, loops, Functions (including lambda functions, Basic file input/output NumPy arrays and basic array operations, Array functions and vectorized computations, Descriptive statistics using NumPy, Random number generation (Uniform, Normal, Binomial, Poisson), Sampling techniques (with and without replacement), Basic matrix operations Data visualization, Introduction to Matplotlib, Line plot, bar diagram, histogram, boxplot, scatter plot, Labels, legends, and basic customization	**CO1, CO3, CO4, CO5**
IV	Data Analysis and Statistical Methods in Python	Data Handling with Pandas, Series, and Data Frame Indexing and slicing, reading and writing CSV files Basic data cleaning and grouping, Descriptive statistics on Data Frames, Plotting with Pandas Statistical Simulation and Inference: Simulation of sampling distributions (mean and proportion), Central Limit Theorem illustration, Confidence intervals (mean and proportion) Hypothesis testing: Z-test (one-sample and two-sample), Paired test, Introduction to nonparametric tests (Sign test) Regression and Basic Modeling: Simple and Multiple Linear Regression, One-way ANOVA, Introduction to Logistic Regression	**CO3, CO4, CO5**

References:

1. Dalgaard, P. (2008). *Introductory statistics with R* (2nd ed.). Springer.
2. Maindonald, J., & Braun, J. (2007). *Data analysis and graphics using R* (2nd ed.). Cambridge University Press.
3. Faraway, J. J. (2005). *Linear models with R*. Chapman & Hall/CRC.
   (Note: Year commonly listed as 2005—confirm if your edition differs.)
4. Hill, C. (2020). *Learning scientific programming with Python*. Cambridge University Press.
5. Agresti, A., & Kateri, M. (2022). *Foundations of statistics for data scientists with R and Python*. CRC Press.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		L		L		L
CO2	H		M	L	L		M
CO3	M		H	H	M	L	M
CO4	M		H	H	M	L	M
CO5	M		H	M	H	L	H
AVG	2.4	0	2.4	1.8	1.8	0.6	2

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SEMESTER: II

Probability Theory

Credit: 4 (T) + 0 (P)
Paper Code: MSTR210T

Course Outcomes (CO):
After completion of the course, the student will be able to:

CO1: Give a more rigorous introduction to the theory of measure.
CO2: Recall the concepts of probability theory and consider them from a measure-theoretic point of view.
CO3: Develop a rigorous understanding of probability spaces and sigma-algebras
CO4: Develop the ideas of Lebesgue integration and its properties.
CO5: Apply probability and measure theory to solve complex statistical problems.

Course Content:

Module No.	Module Name	Chapter Topic	CO

I	**Introduction to Probability Theory**	Fields, semi-fields, sigma-fields, measures, sigma-finite/finite/probability measures, properties, statement of Caratheodory extension theorem. Monotone class theorem.	**CO1**
II	**Measurable Functions**	Measurable functions and properties, Generated sigma-fields. Induced measures. Compositions. Random variables, probability distributions, distribution functions. Product measurable spaces; characterizations; random vectors, multivariate distributions.	**CO2, CO3**
III	**Integration and Radon-Nikodym Theorem**	Integration: simple, nonnegative, general measurable functions, integrability. Expectations, moments. Monotone Convergence Theorem, Fatou's lemma, Dominated Convergence Theorem. Absolute continuity and singularity of measures. Radon-Nikodym Theorem (Statement). Discrete and absolutely continuous distributions, probability densities.	**CO4, CO5**
IV	**Product Measure and Fubini's Theorem**	Product measures. Fubini's theorem. Lebesgue measure on R^k. Independent random variables. Asymptotics of independent random variables: tail sigma-field, Kolmogorov's 0-1 law.	**CO4**
V	**L_p Spaces and Convergence of Distributions**	L_p spaces, L_p-convergence of random variables, connections with other modes of convergence. Convergence in distribution. Connections with other modes of convergence. Slutsky's theorem. Characteristic functions. Convolutions. Inversion and Continuity theorems. Weak and strong laws of large numbers. Central Limit Theorems.	**CO3, CO5**

References:

1. Resnick, I. S. (2019). *A probability path*. Birkhäuser.
2. Billingsley, P. (2012). *Probability and measure* (Anniversary ed.). John Wiley & Sons.
3. Ash, R. B., & Doleans-Dade, C. A. (2000). *Probability and measure theory* (2nd ed.). Academic Press.
4. Athreya, K. B., & Lahiri, S. N. (2006). *Measure theory and probability theory*. Springer.
5. Basu, A. K. (2012). *Measure theory and probability* (2nd ed.). PHI Learning.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	M				H

CO2		H		L		L	M
CO3	H				H		
CO4	H	M		L			M
CO5	H	H	M		H	L	H
AVG	2.4	2	0.8	0.4	1.2	0.4	2

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Statistical Inference

Credit: 3 (T) + 1 (P)
Paper Code: MSTR220C

Course Outcome (CO):

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

CO1: Understand and explain the concepts of sufficiency, completeness, and exponential family of distributions used in parametric estimation.

CO2: Apply different statistical theorems to obtain efficient estimators and analyze their properties.

CO3: Analyze parametric hypothesis testing procedures and confidence sets using concepts like Neyman–Pearson Lemma, UMPU tests, and likelihood ratio methods.

CO4: Apply nonparametric statistical methods to solve practical statistical problems.

CO5: Evaluate nonparametric inference problems involving multi-sample tests and association analysis and interpret results for real-life data analysis.

Module No.	Module Name	Chapter Topics	CO
I	Parametric Estimation	Sufficiency and completeness. Basu's Theorem – statement and application. Complete, sufficient statistics in Exponential family of distributions. Rao-Blackwell Theorem, Lehmann-Scheffe Theorem. UMVUE. Consistency.	CO1, CO2
II	Parametric testing and confidence sets	Generalized Neyman-Pearson Lemma. UMPU tests for Simple and Composite hypotheses. Monotone Likelihood Ratio. Confidence sets. Uniformly Most Accurate (UMA) and Uniformly Most Accurate Unbiased (UMAU) confidence sets	CO3
III	Foundations of Nonparametric Inference	Elementary concepts and properties of U-statistics. Linear Rank Statistics. Single sample location problems. Single	CO4

		sample location cum symmetry problems. Goodness-of-fit problems.	
IV	Multi-sample and Association Problems	Two-sample location problems. Two-sample scale problems. Two-sample homogeneity problems. Multi-sample location problems. Bivariate association problems.	CO5

References:

1. Gibbons, J. D., & Chakraborti, S. (2020). *Nonparametric statistical inference* (6th ed.). CRC Press.
2. Wasserman, L. (2006). *All of nonparametric statistics*. Springer.
3. Tsybakov, A. B. (2009). *Introduction to nonparametric estimation*. Springer.
4. Fraser, D. A. S. (1957). *Nonparametric methods in statistics*. John Wiley & Sons.
5. Lehmann, E. L., & Romano, J. P. (2005). *Testing statistical hypotheses*. Springer.
6. Zacks, S. (1971). *The theory of statistical inference*. John Wiley & Sons.
7. Rao, C. R. (2002). *Linear statistical inference and its applications* (2nd ed.). John Wiley & Sons.
8. Lehmann, E. L., & Casella, G. (1998). *Theory of point estimation* (2nd ed.). Springer.
9. Ferguson, T. S. (1967). *Mathematical statistics: A decision theoretic approach*. Academic Press.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		L
CO2	M		H	L	M	L	M
CO3	M		H	L	M		M
CO4	M		H	L	M	L	M
CO5	M		H	M	H	L	H
AVG	**2.2**	**0.0**	**2.8**	**1.2**	**2.0**	**0.6**	**2.0**

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Bayesian Inference

Credit: 3(T) + 1 (P)
Paper Code: MSTR230C

Course Outcome (CO):

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

CO1: Explain the basic elements of decision theory including decision rules, loss functions, and risk functions.

CO2: Compare and critically evaluate the classical and Bayesian paradigms of statistical inference and justify the choice of priors.

CO3: Perform Bayesian point estimation, interval estimation, and prediction for standard statistical models using common prior distributions.

CO4: Apply Bayesian regression, model selection, and computational methods such as Monte Carlo and MCMC techniques including Gibbs sampling and Metropolis–Hastings algorithm.

CO5: Conduct Bayesian hypothesis testing using Bayes factors and apply Bayesian methods for comparing two population means and hierarchical models in practical problems.

Module No.	Module Name	Chapter Topics	CO
I	Foundations of Decision Theory	Elements of decision theory. Preliminary ideas of decision rules. Loss functions and risk functions.	CO1
II	Classical vs Bayesian Paradigms	Overview and comparison of classical and Bayesian statistical analysis. Relative advantages and disadvantages. Motivation for choice of different priors.	CO2
III	Bayesian Estimation and Prediction	Bayesian inference: point estimation, interval estimation, and prediction for common models and common priors.	CO3
IV	Bayesian Regression and Computational Methods	Bayesian linear regression with conjugate priors. Bayesian model selection. Bayesian Information Criterion (BIC). Monte Carlo method. Markov chains and MCMC. Gibbs sampling. Metropolis–Hastings algorithm. Hierarchical Bayes with examples.	CO4, CO5
V	Bayesian Hypothesis Testing	Bayesian hypothesis testing (one-sided and two-sided examples). Bayes factor. Test for comparing two population means.	CO5

References:

1. Berger, J. O. (1985). *Statistical decision theory and Bayesian analysis* (2nd ed.). Springer.
2. Ghosh, J. K., Delampady, M., & Samanta, T. (2006). *An introduction to Bayesian analysis: Theory and methods*. Springer.
3. Robert, C. P. (2007). *The Bayesian choice: From decision-theoretic foundations to computational implementation* (2nd ed.). Springer.
4. Robert, C. P., & Casella, G. (2004). *Monte Carlo statistical methods* (2nd ed.). Springer.
5. Brooks, S., Gelman, A., Jones, G., & Meng, X. L. (2011). *Handbook of Markov chain Monte Carlo*. Chapman & Hall/CRC.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		L
CO2	H		M		L		L
CO3	M		H	L	M	L	M
CO4	M		H	M	M	L	M
CO5	M		H	M	H	L	H

AVG	**2.4**	**0.0**	**2.6**	**1.0**	**1.8**	**0.6**	**1.8**

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Sample Survey and Design of Experiments

Credit: 3 (T) + 1 (P)
Paper Code: MSTR240C

Course Outcome (CO):

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

CO1: Explain the fundamental principles and properties of block designs.

CO2: Analyze and construct Balanced Incomplete Block Designs (BIBD) and related designs, and perform intra-block and inter-block analysis including treatment of missing observations.

CO3: Apply factorial design techniques, including confounding and balancing in symmetric factorial experiments.

CO4: Understand foundational concepts of probability sampling designs, inclusion probabilities, and obtain estimators for population parameters.

CO5: Apply advanced survey sampling estimators, multi-stage sampling procedures, and sample size determination methods for practical situations.

Module No.	Module Name	Chapter Topics	CO
I	Fundamentals of Block Designs	Block designs. Connectedness. Orthogonality. Balance and efficiency. Resolvable designs.	CO1
II	BIB Designs and Their Extensions	Properties of BIB designs. Designs derived from BIB designs. Intra-block analysis of BIB. Recovery of inter-block information in BIB designs. Missing plot technique. Elementary ideas of Lattice and PBIB designs. Construction of BIBD through mutually orthogonal Latin Squares (MOLS).	CO2
III	Factorial Designs	Factorial designs: analysis. Confounding and balancing in symmetric factorials.	CO3
IV	Fundamentals of Probability Sampling	Notions of sampling design and sampling scheme. Inclusion probabilities. Unequal probability sampling with and without replacement.	CO4
V	Estimation of population total/mean in finite population	Horvitz–Thompson estimator of population total. Hansen–Hurwitz estimator in unequal probability sampling with replacement. Des Raj and Murthy's estimators (for sample size two) in unequal probability sampling without replacement. Ratio and regression estimators. Multi-Stage sampling. Two-stage sampling under different sampling schemes.	CO4, CO5

References:

1. Dey, A. (1986). *Theory of block designs*. John Wiley & Sons.
2. Dey, A. (2010). *Incomplete block designs*. World Scientific.
3. Casella, G. (2008). *Statistical design*. Springer.
4. Montgomery, D. C. (2017). *Design and analysis of experiments* (9th ed.). John Wiley & Sons.
5. Ryan, T. P. (2007). *Modern experimental design*. John Wiley & Sons.
6. Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.
7. Raj, D., & Chandak, N. (1998). *Sampling theory*. Narosa Publishing House.
8. Murthy, M. N. (1967). *Sampling theory and methods*. Statistical Publishing Society.
9. Hedayat, A., & Sinha, B. K. (1991). *Design and inference in finite population sampling*. John Wiley & Sons.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		L
CO2	M		M	L	M		M
CO3	M		H	L	M		M
CO4	M	L	H	L	M	L	M
CO5	M	L	H	M	H	L	H
AVG	**2.2**	**0.4**	**2.8**	**1.0**	**2.0**	**0.4**	**2.0**

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Resampling Techniques and Time Series Analysis

Credit: 3 (T) + 1 (P) **Paper Code: MSTR250C**

Course Outcome (CO):

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

CO1: Explain the principles of permutation tests and resampling-based inference methods.

CO2: Apply jackknife and bootstrap techniques to estimate bias, standard error, and sampling distributions, and construct bootstrap confidence intervals.

CO3: Implement bootstrap methods for regression analysis and assess model uncertainty.

CO4: Understand different types of time series models, their properties and analyze classical and smoothing-based time series models.

CO5: Analyze and forecast time series data and perform diagnostics.

Module No.	Module Name	Chapter Topics	CO
I	Permutation Tests	Concept of permutation tests. some common permutation-based tests. permutation distribution and p-values.	CO1
II	Jackknife and Bootstrap Methods	Jackknife and bootstrap methods. Estimation of bias, standard error and distribution function based on i.i.d. random variables. Standard examples. Different Bootstrap confidence intervals.	CO2
III	Bootstrap Regression	Bootstrap methods in regression analysis. Estimation of regression parameters.	CO3
IV	Introduction to Time Series	Classical time series models. Smoothing techniques: exponential smoothing and Holt–Winters methods.	CO4
V	Stationary Processes	Evolutionary and stationary time series. Autocorrelation and partial autocorrelation functions.	CO4
VI	Box-Jenkins Models	Box-Jenkins Model: Identification, Estimation and Diagnostics. Tests for Unit Roots. Forecasting.	CO5

References:

1. Efron, B., & Tibshirani, R. J. (1993). *An introduction to the bootstrap*. Chapman & Hall/CRC.
2. Efron, B. (1982). *The jackknife, the bootstrap and other resampling plans*. Society for Industrial and Applied Mathematics.
3. Shao, J., & Tu, D. (1995). *The jackknife and bootstrap*. Springer.
4. Chatfield, C. (2004). *The analysis of time series: An introduction* (6th ed.). Chapman & Hall/CRC.
5. Box, G. E. P., Jenkins, G. M., & Reinsel, G. C. (2008). *Time series analysis: Forecasting and control* (4th ed.). John Wiley & Sons.
6. Brockwell, P. J., & Davis, R. A. (2016). *Introduction to time series and forecasting* (3rd ed.). Springer.
7. Pankratz, A. (1983). *Forecasting with univariate Box–Jenkins models*. John Wiley & Sons.
8. Janacek, G., & Swift, L. (1993). *Time series: Forecasting, simulation, applications*. Ellis Horwood.
9. Efron, B. (1979). Bootstrap methods: Another look at the jackknife. *The Annals of Statistics, 7*(1), 1–26.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO1	H		M		L		L
CO2	M		H	L	M	L	M
CO3	M		H	M	M	L	M
CO4	M		H	L	M		M
CO5	M		H	M	H	L	H
AVG	**2.2**	**0.0**	**2.8**	**1.2**	**2.0**	**0.6**	**2.0**

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

SEMESTER: III

Statistical Learning

Credit: 3 (T) + 1 (P)

Paper Code: **MSTR310C**

Course Outcomes (CO):
After completion of the course, the student will be able to:

CO1: Explain supervised vs. unsupervised learning, big data challenges, and the bias-variance trade-off.

CO2: Apply shrinkage methods like Ridge, LASSO, and partial least squares for linear regression.

CO3: Implement kernel methods, GAMs, and smoothing techniques for regression modelling.

CO4: Use tree-based methods including CART and Random Forests for classification tasks.

CO5: Apply k-NN, maximal margin classifiers, and Support Vector Machines for classification.

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Supervised and unsupervised, the 5 v's of a big data problem, the curse of dimensionality. Prediction accuracy vs bias.	**CO1**
II	Generalization of Linear Regression	Shrinkage methods: Ridge Regression and LASSO, Partial least squares.	**CO2**
III	Other Regression Methods	Kernel-based methods, GAM, Smoothing techniques.	**CO3**

IV	Tree-based Classification methods	Classification and Regression Trees (CART), Random Forest.	**CO4**
V	Other Classification methods	k-Nearest Neighbour method. The maximal margin classifier and separability, Support Vector Machine.	**CO5**
VI	Neural Networks	Ideas and basic illustrations.	**CO5**

Course Contents:

References:

1. Friedman, B. L., & others. (1984). *Classification and regression trees*. Wadsworth.
2. Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
3. Friedman, J., Hastie, T., & Tibshirani, R. (2009). *The elements of statistical learning: Data mining, inference, and prediction* (2nd ed.). Springer.
4. Johnson, R. A., & Wichern, D. W. (2014). *Applied multivariate statistical analysis* (6th ed.). Pearson.
5. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An introduction to statistical learning: With applications in R* (2nd ed.). Springer.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**H**	**-**	**M**	**L**	**L**	**-**	**L**
CO2	**H**	**-**	**H**	**M**	**M**	**-**	**M**
CO3	**H**	**-**	**H**	**M**	**M**	**-**	**M**
CO4	**H**	**M**		**L**			**M**
CO5	**M**	**-**	**H**	**M**	**M**	**-**	**H**
AVG	**2.8**	**0.4**	**2.2**	**1.6**	**1.4**	**0**	**2**

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Introduction to Research and Dissertation

Paper Code: **MSTR320J**

Course Type: **Project**

Credit:**4**

Marks: **100**

Optimization Techniques

Credit: 3 (T) + 1 (P)
Paper Code: MSTR331C

Course Outcomes (CO):
After completion of the course, the student will be able to:

CO1: Give a more rigorous introduction to the theory of optimization.
CO2: Understand how to mathematically formulate a decision-making problem to make the optimum decision
CO3: Apply knowledge of optimization techniques in real-life decision-making problems.
CO4: Analyse real life decision-making situations to take the best decision subject to the given resources.
CO5: Develop the ability to identify problems that require optimization techniques.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	**Linear Programming**	An introduction. Motivation of simplex method for solving a linear programming problem; Simplex algorithm and construction of simplex tableau; Minimization versus maximization problems. Duality in LP; Primal-dual relations; Dual Simplex method.	**CO1, CO2**
II	**Integer programming**	Integer linear programming and mixed integer linear programming. Concept of cutting plane method. Branch and bound algorithm. Examples.	**CO2, CO3, CO5**
III	**Dynamic programming**	Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and Bellman's principle of optimality. Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming	**CO3, CO4**
IV	**Non-linear programming**	Multivariate optimization problem with inequality constraints. Kuhn-Tucker conditions. Convex programming, Quadratic Programming – Wolfe's algorithm.	**CO4**
V	**Goal programming**	An introduction. Formulation of goal programming problem. Partitioning algorithm.	**CO3, CO5**

References:

1. Hadley, G. (1962). *Linear programming*. Addison-Wesley.

2. Hadley, G. (1964). *Nonlinear and dynamic programming*. Addison-Wesley.
3. Murty, K. G. (1976). *Linear and combinatorial programming*. John Wiley & Sons.
4. Kambo, N. S. (1984). *Mathematical programming techniques*. Affiliated East-West Press.
5. Rao, S. S. (1984). *Optimization: Theory and applications* (2nd ed.). John Wiley & Sons.
6. Mittal, K. V., & Mohan, C. (1972). *Optimization methods in operations research and systems analysis*. New Age International.
7. Gass, S. I. (2003). *Linear programming: methods and applications*. Courier Corporation.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		
CO2	H		H		M		
CO3	M		H	M	H	L	L
CO4	M		H	M	H	M	L
CO5	M		M		M		
AVG	**2.4**		**2.6**	0.8	**2.2**	**0.6**	0.4

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Advanced Statistical Inference

Credit: 3 (T) + 1 (P)
Paper Code: MSTR341C

Course Outcomes (CO):
After successful completion of the course, the students will be able to:

CO1. Understand and explain the Behrens–Fisher problem and its generalizations.
CO2. Apply statistical techniques to test hypotheses about population means and construct confidence intervals.
CO3. Analyze multiple testing procedures while controlling familywise error rate and false discovery rate.
CO4. Apply nonparametric estimation techniques for distribution-free analysis.
CO5. Evaluate the efficiency of statistical procedures and interpret their effectiveness in statistical inference problems.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Behrens–Fisher Problem	Behrens–Fisher problem and its generalisation. Scheffé's solution in the univariate case and its multivariate extension. Welch's approach.	CO1
II	Testing Mean in Normal Setup	Devising a test with power independent of σ^2. Stein's two-step procedure. Confidence interval for μ with previously fixed length.	CO2
III	Multiple Testing Procedures	Concept of multiple testing. Familywise error rate. Bonferroni and Holm's procedures. False discovery rate. Benjamini–Hochberg procedure.	CO3
IV	Nonparametric Estimation and Efficiency	Nonparametric interval estimation. Kernel density estimation. Concept of asymptotic relative efficiency (ARE)	CO4, CO5

References:

1. Lehmann, E. L., & Romano, J. P. (2005). *Testing statistical hypotheses*. Springer.
2. Serfling, R. J. (1980). *Approximation theorems of mathematical statistics*. John Wiley & Sons.
3. Muirhead, R. J. (1982). *Aspects of multivariate statistical theory*. John Wiley & Sons.
4. Hochberg, Y., & Tamhane, A. C. (1987). *Multiple comparison procedures*. John Wiley & Sons.
5. Gibbons, J. D., & Chakraborti, S. (2020). *Nonparametric statistical inference* (6th ed.). CRC Press.
6. Tsybakov, A. B. (2009). *Introduction to nonparametric estimation*. Springer.
7. Fraser, D. A. S. (1957). *Nonparametric methods in statistics*. John Wiley & Sons.

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		L
CO2	M		H	L	M	L	M
CO3	M		H	L	M		M
CO4	M		H	M	M	L	M
CO5	M		H	M	H	L	H
AVG	**2.2**	**0.0**	**2.8**	**1.4**	**2.0**	**0.6**	**2.0**

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Demography & Development Statistics

Credit: 3 (T) + 1 (P)
Paper Code: MSTR351C

Course Outcomes (CO):

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

CO1: Explain sources of demographic data, population composition, and key measures of mortality and fertility.
CO2: Evaluate the quality of demographic data using techniques for detecting and adjusting age misreporting and other data errors.
CO3: Apply demographic models and statistical methods for population estimation, projection, and analysis of migration and mobility.
CO4: Describe the role of statistics in economic development, including national income estimation and statistical systems.
CO5: Assess levels of development using measures of poverty, inequality, unemployment, and composite development indices.

Course Content:

Module No.	Module Name	Chapter Topics	CO
I	Demographic Data and Population Composition	Sources of demographic data and common coverage and content errors in demographic data. Balancing equation of population change. Population composition: age and sex structure. Adjustment of age data: methods for detecting age misreporting using Whipple's Index and Myer's Blended Index. Dependency ratio and its interpretation. Measures and determination of urbanisation.	**CO1, CO2**
II	Mortality and Fertility Analysis	Measures of mortality. Life tables. Abridged life tables - Construction Measures of fertility. Stochastic models of fertility and population growth. Logistic curve, stable and quasi-stable population, and intrinsic growth rate.	**CO1, CO3**
III	Population Dynamics and Demographic Modelling	Population estimation and projection. Methods of population projection. Population projection using the Leslie Matrix. Stochastic models for migration. Social and occupational mobility models	**CO3**

IV	Concept of Economic Development	Role of Statistics, National and international statistical systems. National accounts – estimation of national income.	**CO4**
V	Different Measures for assessing development	Measurement of Poverty, Measurement of Inequality and Unemployment	**CO5**
VI	Development Indices	Human Development and Multi-dimensional Poverty Indices.	**CO5**

References:

1. Bartholomew, D. J. (1982). *Stochastic models for social processes* (3rd ed.). John Wiley & Sons.
2. Chiang, C. L. (1968). *Introduction to stochastic processes in biostatistics*. John Wiley & Sons.
3. Cox, P. R. (1970). *Demography*. Cambridge University Press.
4. Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography*. Springer Science & Business Media.
5. Shryock, H. S., Siegel, J. S., & Larmon, E. A. (1973). *The methods and materials of demography*. U.S. Bureau of the Census.
6. Central Statistical Organisation. (2007). *National accounts statistics: Sources and methods*. Government of India.
7. Grusky, D. B., Kanbur, S. R., & Sen, A. K. (2006). *Poverty and inequality*. Stanford University Press.
8. Chaubey, P. K. (1995). *Poverty Measurement: Issues, Approaches, and Indices*. New Age International Publishers.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	L	L	L	L	M
CO2	H	M	M	M	M	M	H
CO3	H	H	M	H	M	M	M
CO4	H	M	L	M	L	L	H
CO5	H	H	M	M	M	M	H
Average	3.0	2.4	1.6	2.0	2.2	1.6	2.6

***H means High relevance (3), M means medium relevance (2), L means Low relevance (1)

Operations Research

Credit: 3 (T) + 1 (P)
Code: MSTR362C

Course Outcomes (CO):

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

CO1: Introduce basic concepts and components essential to Operations Research (OR).

CO2: Understand the theoretical frameworks and methodologies involved in Operations Research

CO3: Apply OR techniques and algorithms to solve real life problems.

CO4: Analyze different decision-making environments and suggest appropriate tools to use in each.

CO5: Evaluate the effectiveness of different models and policies in order to come to a decision.

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Introduction to Operations Research. Scope of Operations Research. Phases in Operations Research.	CO1, CO2
II	Game Theory	Decision-making under uncertainty and risk, Use of different criteria. Decision-making in the face of competition, Two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2×2, $2 \times m$ and $m \times n$ games. Nonzero-sum game.	CO3, CO4
III	Inventory Control and Routing problem	Analytical structure of inventory problems, EOQ formula of Harris & Wilson, its sensitivity analysis and its extensions allowing quantity discounts and shortages. The static risk model. P and Q- systems with constant and random lead times. Airline problem. ABC analysis. Travelling salesman problem. Branch and bound method.	CO3, CO5
IV	Queuing Theory	Specifications and effectiveness measures in queuing theory. Steady-state solutions of M/M/1, M/M/c M/M/c/N. M/G/1 queues. Pollazcek-Khinchine result. Machine interference problem, Little's formula.	CO3, CO4
V	Project management and Network analysis	Construction of the Network diagram. Critical Path-float, Slack analysis, Total float. Free float, independent float. PERT, Time-Cost Optimization Algorithm. Project Time Crashing.	CO5

References:

1. Taha, H. A. (2017). *Operations research: An introduction* (10th ed.). Pearson.
2. Hillier, F. S., & Lieberman, G. J. (2015). *Introduction to operations research* (10th ed.). McGraw-Hill Education.
3. Phillips, D. T., Ravindran, A., & Solberg, J. J. (1976). *Operations research: Principles and practice*. John Wiley & Sons.
4. Churchman, C. W., Ackoff, R. L., & Arnoff, E. L. (1957). *Introduction to operations research*. John Wiley & Sons.

5. Starr, M. K., & Miller, D. W. (1962). *Inventory control: Theory and practice*. Prentice Hall.
6. Hadley, G., & Whitin, T. M. (1963). *Analysis of inventory systems*. Prentice Hall.
7. Kleinrock, L. (1975). *Queueing systems: Volume 1 – Theory*. John Wiley & Sons.
8. Sasieni, M. W., Yaspan, A., & Friedman, L. (1959). *Operations research: Methods and problems*. John Wiley & Sons.
9. Sasieni, M. W., & Ackoff, R. L. (1961). *Operations research*. John Wiley & Sons.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		M
CO2	H		M	L	M		M
CO3	M		H	M	H	M	H
CO4	M		H	M	H	M	H
CO5	M		H	M	H	H	M
Average	2.4	0	2	1.4	2.4	1.4	2.4

***__H__ means High relevance (3), __M__ means medium relevance (2), __L__ means Low relevance(1)

Reliability Theory

Credit: 3 (T) + 1 (P)
Code: MSTR373T

Course Outcomes (CO):

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

CO1: Introduce basic concepts that are essential for understanding lifetime distributions of products / equipments.

CO2: Understand how to deal with data that relates to failure times of products/equipments.

CO3: Apply acquired knowledge of reliability analysis to draw logical conclusions in situations where components and systems fail randomly

CO4: Analyze real lifetime data by using appropriate reliability analysis tools

CO5: Develop the skill to build appropriate regression models for reliability function for given covariates

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Reliability concepts and measures. Common univariate lifetime distributions. Reliability function, hazard rate, Mean residual life. Ageing classes. Loss of memory property. Partial ordering of lifetime distributions.	CO1
II	Systems	Systems with independent components. Coherent systems, reliability of coherent systems. Preservation of ageing classes in systems under reliability operations. Systems with dependent components. Bivariate fatal shock model. Marshall-Olkin bivariate exponential distribution and its properties.	CO3
III	Censoring and inference based on censored data	Types of censoring. Parametric and non-parametric estimation of reliability function based on censored failure time data. Kaplan – Meier estimation of reliability curve, Nelson-Aalen estimation of hazard function, Greenwood formula. Non – parametric methods for comparing several reliability curves, Log rank tests.	CO2, CO4
IV	Regression models in reliability theory	Cox proportional hazard and Accelerated failure time models. Estimation of parameters and diagnostics	CO5
V	Replacement policies	Deterministic models, Preventive replacement policies. Staffing Problem.	CO3

References:

1. Barlow, R. E., & Proschan, F. (1975). Statistical theory of reliability and life testing: Probability models. Holt, Rinehart and Winston.

2. Lawless, J. F. (2003). Statistical models and methods for lifetime data (2nd ed.). John Wiley & Sons.

3. Bain, L. J., & Engelhardt, M. (1991). Statistical analysis of reliability and life-testing models: Theory and methods. Marcel Dekker.

4. Zacks, S. (1992). Introduction to reliability analysis: Probability models and statistical methods. Springer.

5. Kalbfleisch, J. D., & Prentice, R. L. (2002). The statistical analysis of failure time data (2nd ed.). John Wiley & Sons.

6. Smith, P. J. (2002). Analysis of failure and survival data. Chapman & Hall/CRC.

7. Lai, C. D., & Xie, M. (2006). Stochastic ageing and dependence for reliability. Springer.

8. Gertsbakh, I. B. (2000). Reliability theory with applications to preventive maintenance. Springer.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		M
CO2	M	L	H	M	M		M
CO3	M		H	M	H	L	H
CO4	M		H	H	M		H
CO5	M		H	H	M		H
Average	2.2	0.2	2.8	2	2	0.2	2

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance(1)

Survival Analysis

Credit: **3(T) + 1(P)**

Paper Code: MSTR382C

Course Outcomes (CO):

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

CO1: Explain fundamental concepts of survival analysis, including survival measures and the application of common univariate survival time distributions.

CO2: Apply survival analysis techniques to handle truncation and different types of censored data using parametric and non-parametric estimation methods.

CO3: Estimate survival and hazard functions from censored life-test data using methods such as Actuarial, Kaplan–Meier, and Nelson–Aalen estimators.

CO4: Analyze and compare survival distributions using parametric and non-parametric statistical tests and regression models.

CO5: Evaluate complex survival data structures using advanced models including competing risks, multivariate survival models, and frailty models.

Course Content:

Module No.	Module Name	Chapter Topics	CO
I	Introduction	Survival concepts and measures. Survival function, hazard function, cumulative hazard function, Mean remaining life. Common univariate survival time distributions.	CO1
II	Censoring and truncation	Truncation and censoring. Types of censoring. Estimation based on survival times from variously censored life-tests data for parametric families. Non-parametric estimation with censored data - Actuarial, Kaplan-Meier and Nelson-Aalen estimators. Greenwood formula.	CO2
III	Tests of survival functions	Parametric methods for comparing two survival distributions - Likelihood Ratio test, Cox's F-test Non – parametric methods for comparison of several reliability curves, Log rank tests. Gehan's and Mantel-Haenszel tests.	CO3
IV	Regression models	Cox proportional hazard model – estimation, tests, Cox-Snell residuals. Additive Models. Accelerated failure time model.	CO4
V	Other relevant models	Competing Risk and Multivariate Survival models. Frailty Models.	CO5

References:

1. Klein, J. P., & Moeschberger, M. L. (1997). *Survival analysis: Techniques for censored and truncated data*. Springer.
2. Kleinbaum, D. G., & Klein, M. (2005). *Survival analysis: A self-learning text* (2nd ed.). Springer.
3. Miller, R. G. (1981). *Survival analysis*. Wiley.
4. Smith, P. J. (2002). *Analysis of failure and survival data*. Chapman & Hall/CRC.
5. Kalbfleisch, J. D., & Prentice, R. L. (2002). *The statistical analysis of failure time data* (2nd ed.). Wiley.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	L	L	L	L	M
CO2	H	M	M	M	M	M	H

CO3	H	H	M	H	M	M	M
CO4	H	M	L	M	L	L	H
CO5	H	H	M	M	M	M	H
Average	3.0	2.4	1.6	2.0	2.2	1.6	2.6

***H** means High relevance (3), **M** means medium relevance (2), **L** means Low relevance(1)

Clinical Trials

Credit: **3(T)+1(P)**

Paper Code: **MSTR393C**

Course Outcome (COs):

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

CO1: Explain the basic concepts, phases, and types of clinical trials.

CO2: Describe ethical principles and regulatory guidelines governing clinical trials.

CO3: Determine appropriate sample size and understand interim monitoring in clinical trials.

CO4: Apply randomization techniques for treatment allocation in randomized clinical trials.

CO5: Analyze response-adaptive randomization methods to favor better performing treatments.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Introduction to Clinical Trials	Introduction to clinical trials; phases of clinical trials; objectives and basic terminology.	CO1
II	Ethical and Regulatory Issues in Clinical Trials	Ethical issues in clinical trials: informed consent, risk–benefit assessment, role of ethics committees, regulatory guidelines. Types of clinical trials: exploratory vs confirmatory trials, superiority, non-inferiority, equivalence trials.	CO2
III	Sample Size Determination and Interim Monitoring	Sample size determination: concepts of power, significance level, effect size; sample size for comparing proportions and means. Group sequential monitoring.	CO3
IV	Randomization Techniques in	Randomized clinical trials: randomization for balancing treatment assignments (random	CO4

	Clinical Trials	allocation rule, truncated binomial design, biased coin designs), incorporating covariate information.	
V	Response-Adaptive Randomization Methods	Randomization to favour the better performing treatments for binary responses (play-the-winner and randomized-play-the-winner rules).	CO5

References:

1. Piantadosi, S. (2005). *Clinical trials: A methodologic perspective* (2nd ed.). John Wiley & Sons.
2. Everitt, B. S., & Pickles, A. (2004). *Statistical aspects of the design and analysis of clinical trials*. Imperial College Press.
3. Pocock, S. J. (1983). *Clinical trials: A practical approach*. John Wiley & Sons.
4. Whitehead, J. (1997). *The design and analysis of sequential clinical trials* (2nd ed.). John Wiley & Sons.
5. Rosenberger, W. F., & Lachin, J. M. (2016). *Randomization in clinical trials: Theory and practice* (2nd ed.). John Wiley & Sons.
6. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., & Granger, C. B. (2015). *Fundamentals of clinical trials*. Springer.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		H
CO2	M		L		M	H	H
CO3	H		H	M	M		H
CO4	M		H	M	H		H
CO5	M		H	M	H	M	H
Average	2.4	0	2.4	1.2	2.2	1	3

***__H__ means High relevance (3), __M__ means medium relevance (2), __L__ means Low relevance (1)

Actuarial Statistics

Credit: 3(T)+1(P)

Paper Code: **MSTR3102C**

Course Outcomes (CO):

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

CO1: Understand individual and aggregate insurance losses using appropriate probability distributions and estimation techniques.

CO2: Apply risk and compound models to analyse aggregate insurance claims.

CO3: Apply credibility theory and experience rating methods for insurance premium determination.

CO4: Analyse outstanding claim liabilities using run-off triangles and standard actuarial reserving methods.

CO5: Analyse results to support sound insurance decision-making.

Course Content:

Module No	Module Name	Lecture Topic	CO
I	Loss Distributions and Reinsurance	Modelling individual and aggregate losses, Moments of loss distributions Fitting distributions to claims data Deductibles and retention limits Proportional and excess-of-loss reinsurance, Share of claim amounts between insurer and reinsurer	CO1
II	Risk Models for insurance portfolios	Models for claim number and claim amount in short-term insurance contracts, Collective risk model Compound distributions for aggregate claims	CO2
III	Credibility theory and Experience Rating	Introduction to credibility theory, Bayesian approach to credibility, Basic credibility models, Experience rating methods in insurance and banking, Claim probability calculation	CO3, CO5
IV	Claims Reserving and Run-off Triangles	Delay / run-off triangles in insurance, Development factors, Chain-ladder method (basic and inflation-adjusted), Alternative reserving methods, Average cost per claim method, Bornhuetter–Ferguson method	CO4, CO5

References:

1. Klugman, S. A., Panjer, H. H., & Willmot, G. E. (2019). *Loss models: From data to decisions* (5th ed.). John Wiley & Sons.

2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). *Actuarial mathematics*. Society of Actuaries.
3. Kaas, R., Goovaerts, M., Dhaene, J., & Denuit, M. (2008). *Modern actuarial risk theory: Using R* . Springer.
4. Daykin, C. D., Pentikäinen, T., & Pesonen, M. (1994). *Practical risk theory for actuaries*. Chapman & Hall.
5. Ohlsson, E., & Johansson, B. (2010). *Non-life insurance pricing with generalized linear models*. Springer.
6. Taylor, G. C. (2000). *Loss reserving: An actuarial perspective*. Springer.
7. Herzog, T. N. (1999). *Introduction to credibility theory*. ACTEX Publications.
8. Wüthrich, M. V., & Merz, M. (2008). *Stochastic claims reserving methods in insurance*. John Wiley & Sons.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	L	L	L	L	M
CO2	H	M	M	M	M	M	H
CO3	H	H	M	H	M	M	M
CO4	H	M	L	M	L	L	H
CO5	H	H	M	M	M	M	H
Average	3.0	2.4	1.6	2.0	2.2	1.6	2.6

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance (1)

Econometrics

Credit: **3(T)+1(P)**

Paper Code: **MSTR3113C**

Course Outcomes (CO):
After successful completion of the course, the students will be able to:

CO1: Explain the concepts and applications of single-equation econometric models.

CO2: Analyse the consequences of measurement errors and suggest appropriate remedial measures.

CO3: Apply identification and estimation techniques to simultaneous equation models.

CO4: Apply panel data econometric techniques by estimating one-way and two-way fixed and random effects models and conducting diagnostic tests to select appropriate models for data analysis.

CO5: Interpret causal relationships in time-series data.

Course Content:

Module No.	Module Name	Topics	CO
I	Single Equation Models	Censored Data, Lagged Variables	**CO1**
II	Measurement errors	Errors-in-variables and Proxy variables – consequences, and remedial measures	**CO2**
III	Simultaneous Equations	Identification & estimation. SUR model.	**CO3**
IV	Panel Data	One-way and two-way fixed and random effect models. Test for Poolability, Hausman's Test	**CO4**
V	Causality	Granger causality, VAR and VARMA Models, exogeneity, Error Correction Model	**CO5**
VI	Cointegration	Ideas and basic illustrations	**CO5**

References:

1. Johnston, J. (1984). *Econometric methods* (3rd ed.). McGraw-Hill.
2. Judge, G. G., Griffiths, W. E., Hill, R. C., Lütkepohl, H., & Lee, T.-C. (1985). *The theory and practice of econometrics* (2nd ed.). Wiley.
3. Gujarati, D. N. (2003). *Basic econometrics* (4th ed.). McGraw-Hill.
4. Greene, W. H. (2018). *Econometric analysis* (8th ed.). Pearson.
5. Malinvaud, E. (1970). *Statistical methods in econometrics*. North-Holland.
6. Baltagi, B. H. (2021). *Econometric analysis of panel data* (6th ed.). Springer.
7. Intriligator, M. D., Bodkin, R. G., & Hsiao, C. (1996). *Econometric models, techniques, and applications* (2nd ed.). Prentice Hall.
8. Maddala, G. S., & Kim, I.-M. (1998). *Unit roots, cointegration, and structural change*. Cambridge University Press.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	M	L	L	L	L	M
CO2	H	M	M	M	M	M	H
CO3	H	H	M	H	M	M	M
CO4	H	M	L	M	L	L	H
CO5	H	H	M	M	M	M	H
Average	3.0	2.4	1.6	2.0	2.2	1.6	2.6

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance (1)

SEMESTER: IV

Project based Internship

Paper Code: **MSTR410J**

Course Type: **Project**

Credit:**4**

Marks: **100**

Dissertation

Paper Code: **MSTR420J**

Course Type: **Project**

Credit:**12**

Marks: **300**

Statistical Quality Management

Credit: **3 (T) + 1 (P)**

Paper Code: **MSTR434C**

Course Outcomes (CO):

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

CO1: Recall and explain the fundamental concepts of statistical quality management

CO2: Apply univariate control chart techniques for monitoring process performance.

CO3: Analyze process behavior using progressive and advanced control charts and multivariate control charts.

CO4: Evaluate and design sampling inspection plans using attribute and variable sampling methods.

CO5: Explain and apply the principles of Six Sigma methodology for process improvement and quality enhancement.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Introduction to statistical quality management, and control charts. Measures of effectiveness of control charts.	CO1
	Univariate Control charts	Modified $\overline{X}$ chart, Group control chart. Extreme value chart, $(\overline{X}, R)$ charts used jointly. Economic design of control chart. Process capability indices	CO1, CO2
II	Progressive Control Charts and Multivariate Control Charts	Benefits of progressive control charts. Moving average and exponentially weighted moving average charts for mean. Cu-sum chart for mean using V-masks and decision intervals. Multivariate control charts for mean.	CO3
III	Sampling Inspection Plans	Tolerance limits and specification limits. Sampling inspection plans by attribute and by variables. Inspection plans with one or two-sided specifications. Curtailed and semi-curtailed inspection plans. Continuous sampling inspection plans - Dodge type plans and Wald-Wolfowitz plan.	CO4
IV	Six Sigma quality	Basic concept of Six Sigma methodology. DMAIC approach in Six Sigma.	CO5

References:

1. Montgomery, D. C. (2009). *Introduction to statistical quality control* (6th ed.). John Wiley & Sons.
2. Ott, E. R. (1975). *Process quality control: Troubleshooting and interpretation of data*. McGraw–Hill.
3. Wetherill, G. B. (1977). *Sampling inspection and quality control* (2nd ed.). Chapman & Hall.
4. Wetherill, G. B., & Brown, D. W. (1991). *Statistical process control: Theory and practice*. Chapman & Hall.
5. Ryan, T. P. (2000). *Statistical methods for quality improvement* (2nd ed.). John Wiley & Sons.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	-	L	-	-	-	L
CO2	H	-	H	M	M	-	M
CO3	H	-	H	M	M	-	H
CO4	M	L	H	L	H	-	M
CO5	M	-	M	L	H	M	M
Average	2.6	0.4	2.4	1.2	2	0.4	2

***H** means High relevance (3), **M** means medium relevance (2), **L** means Low relevance(1)

Supply Chain Management

Credit: **3 (T) + 1 (P)**

Paper Code: **MSTR444C**

Course Outcomes (CO):

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

CO1: Introduce the concept of supply chain management and its importance in industry.

C02: Understand the dynamics of supply chains

CO3: Apply acquired knowledge to determine the framework to be employed in order to optimize complex supply chain processes

CO4: Analyze supply chain issues and make concrete improvement

CO5: Develop the ability to plan and execute supply chains

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO
I	Introduction to Supply Chain Management	Concept of Supply Chain Management (SCM), and its importance and scope. Supply chain networks, Integrated supply chain planning, supply chain flows. An overview of supply chain models and modeling systems. Functions of SCM. Customer service dimensions from perspective of SCM. Buyers' and Suppliers' Perspectives. Value chain. SCM as a Philosophy of Management.	CO1, CO2
II	Planning and Performance	Strategic, operational and tactical planning of Supply Chains. Supply chain strategies. Performance achieving strategic fit through different steps, Obstacles to achieving Strategic Fit. Supply chain performance measurement - Supply chain drivers, Metrics and obstacles, The balanced score card approach, Performance Metrics.	CO2, CO5
III	Demand Management	Types of demand. Role of demand forecasting in SCM. Factors of Demand Forecast, Basic approach to Demand Forecasting, Aggregate planning in supply chain. Managing predictable variability	CO3, CO4
IV	Inventory Management and	Introduction to Supply Chain Inventory Management. Multi-echelon inventory systems. Bullwhip effect. Role of transportation in a supply chain - direct shipment, warehousing, crossdocking; push vs. pull	CO3, CO4

	distribution management	systems; transportation decisions (mode selection, fleet size), Decisions on facilities in a supply chain, Supply chain facility layout and capacity planning, Designing Distribution Networks and Applications to eBusiness, Information Technology in a Supply Chain.	
V	Cost Management	Pricing and Revenue Management in Supply Chain, Volume leveraging and cross docking, target pricing, Measuring service levels in supply chains, Customer Satisfaction / Value / Profitability.	CO4, CO5

References:

1. Chopra, S., Meindl, P., & Kalra, D. V. (2007). *Supply chain management*. Pearson Education.

2. Chopra, S., & Meindl, P. (2004). *Supply chain management: Strategy, planning and operation* (2nd ed.). Pearson Education.

3. Raghuram, G., & Rangaraj, N. (2000). *Logistics and supply chain management: Cases and concepts*. Macmillan.

4. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2003). *Designing and managing the supply chain: Concepts, strategies, and case studies* (2nd ed.). McGraw-Hill/Irwin.

5. Handfield, R., & Nichols, E. (1999). *Introduction to supply chain management*. Prentice Hall.

6. Mentzer, J. T. (2001). *Supply chain management*. Sage Publications.

7. Rushton, A., Oxley, J., & Croucher, P. (2004). *The essentials of supply chain management*. Jaico Publishing House.

8. Mohanty, R. P., & Deshmukh, S. G. (2005). *Supply chain management: Theories and practices*. Wiley India.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	M		L		L		H
CO2	M		M		M		H
CO3	M		H	M	H	M	H
CO4	M		H	M	H	M	H
CO5	M		H	M	H	H	H
Average	2	0	2.4	1.2	2.4	1.4	3

***H means High relevance (3), M means medium relevance (2), L means Low relevance(1)

Epidemiology

Credit: **3 (T) + 1 (P)**

Paper Code: **MSTR454C**

Course Outcomes (CO):
After successful completion of the course, the students will be able to:

CO1: Understand the basic concepts of epidemiology and different epidemiological study designs.

CO2: Explain standard measures of disease frequency and association using rates and proportions.

CO3: Understand the concepts of confounding and effect modification in epidemiological studies.

CO4: Apply the principles of design and analysis of cohort, case–control, and matched studies.

CO5: Interpret the concept of causality and its measurement in epidemiological research.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Introduction	Definition of epidemiology. Case studies on John Snow and the Lambeth cholera epidemic. Study Designs: Ecological, Cross-sectional, Cohort, Case-Control and its variants. Prospective and Retrospective studies.	**CO1**
II	Standard Measures	Measures of Disease frequency and association based on rates and proportions.	**CO2**
III	Confounding	Confounding and effect modification.	**CO3**
IV	Case-Control and Cohort studies	The design and analysis of cohort and case-control studies.	**CO4**
V	Matched Studies	The design and analysis of matched studies.	**CO4**
VI	Causality	Concept and measurement of causality.	**CO5**

References:

1. Rothman, K. J., Greenland, S., & Lash, T. L. (2008). *Modern epidemiology* (3rd ed.). Lippincott Williams & Wilkins.
2. Selvin, S. (2004). *Statistical analysis of epidemiologic data* (3rd ed.). Oxford University Press.
3. McNeil, D. (1996). *Epidemiological research methods*. John Wiley & Sons.

4. Jekel, J. F., Elmore, J. G., & Katz, D. L. (2007). *Epidemiology, biostatistics, and preventive medicine* (3rd ed.). Saunders Elsevier.
5. Breslow, N. E., & Day, N. E. (1980). *Statistical methods in cancer research: Vol. 1. The analysis of case–control studies*. International Agency for Research on Cancer.
6. Breslow, N. E., & Day, N. E. (1987). *Statistical methods in cancer research: Vol. 2. The design and analysis of cohort studies*. International Agency for Research on Cancer.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	-	L	-	-	-	L
CO2	H	-	H	M	M	-	M
CO3	H	-	H	M	M	-	H
CO4	M	L	H	L	H	-	M
CO5	M	-	M	L	H	M	M
Average	2.6	0.4	2.4	1.2	2	0.4	2

*** **H** means High relevance, **M** means medium relevance, **L** means Low relevance

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Statistical Genetics

Credit: **3 (T) + 1 (P)**

Paper Code: **MSTR464C**

Course Outcomes (COs):

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

CO1: Explain the fundamental concepts of genetics and genetic variation.

CO2: Describe gene mapping methods and principles of population genetics and coalescent theory.

CO3: Apply phylogenetic reconstruction techniques to analyze evolutionary relationships.

CO4: Analyze pedigree data and perform familial aggregation, segregation, linkage, and association studies.

CO5: Evaluate the role of genetic factors in human diseases and analyze complex and quantitative traits.

COURSE CONTENT:

Module No.	Module Name	Chapter Topic	CO

I	Fundamentals of Genetics	Introduction to genetics.	CO1
II	Gene Mapping and Population Genetics	Gene mapping, sequence data, population genetics, and coalescent theory.	CO2
III	Phylogenetic Analysis	Phylogeny reconstruction.	CO3
IV	Pedigree and Family-Based Genetic Analysis	Pedigree analysis; familial aggregation, segregation, linkage and association.	CO4
V	Genetic Epidemiology and Complex Traits	Genetic epidemiology, role of genetic factors in human diseases; analysis of complex and quantitative traits.	CO5

References:

1. Liu, B. H. (1998). *Statistical genomics: Linkage, mapping, and QTL analysis*. CRC Press.
2. Neale, B. M., Ferreira, M. A. R., Medland, S. E., & Posthuma, D. (2016). *Statistical genetics: Gene mapping through linkage and association*. CRC Press.
3. Laird, N. M., & Lange, C. (2011). *The fundamentals of modern statistical genetics*. Springer.
4. Lynch, M., & Walsh, B. (1998). *Genetics and analysis of quantitative traits*. Sinauer Associates.
5. Felsenstein, J. (2004). *Inferring phylogenies*. Sinauer Associates.
6. Yang, Z. (2006). *Computational molecular evolution*. Oxford University Press.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H	L	L		L		L
CO2	H	M	M	L	M		M
CO3	M		H	M	M		M
CO4	M	M	H	M	H	L	H
CO5	M	L	H	M	H	M	H
Average	2.4	1.2	2.4	1.4	2.2	0.6	2.2

***H means High relevance (3), M means medium relevance (2), L means Low relevance(1)

Advanced Time Series

Credit: **3 (T) + 1 (P)**

Paper Code: **MSTR474C**

Course Outcomes (CO):
After successful completion of the course, the students will be able to:

CO1: Understand and apply ARCH and GARCH models to analyse and forecast volatility in financial and economic time series data.

CO2: Formulate State Space Models and implement Kalman Filtering techniques for estimation and prediction of dynamic systems.

CO3: Analyse multivariate time series using VAR and VARMA models, and interpret cross-correlation structures through Portmanteau testing.

CO4: Identify and apply appropriate multivariate volatility models to real-world data and interpret their results meaningfully.

CO5: Examine advanced topics including cointegration, threshold models, extreme value theory, and spectral density analysis for comprehensive time series investigation.

Course Content:

Module No.	Module Name	Chapter Topic	CO
I	Volatility	ARCH, GARCH models and their variants	**CO1**
II	State Space Model	State Space Models and Kalman Filtering	**CO2**
III	Multivariate Models	Cross-correlation matrices and their interpretation. Portmanteau Test. VAR, VARMA.	**CO3**
IV	Multivariate Volatility Models	Different models and their interpretations	**CO4**
V	Some other topics	Cointegrated VAR models. Threshold Cointegration and Arbitrage. Extreme Value, Quantile Estimation, Value at Risk.	**CO5**

VI	Analysis in the Frequency Domain	Spectral Density function, Periodogram analysis	**CO5**

References:

1. Brockwell, P. J., & Davis, R. A. (2016). *Introduction to time series and forecasting* (3rd ed.). Springer.
2. Dey, D. K., & Yan, J. (Eds.). (2016). *Extreme value modeling and risk analysis: Methods and applications*. Chapman & Hall/CRC.
3. Dhrymes, P. J. (1998). *Time series, unit roots, and cointegration*. Academic Press.
4. Francq, C., & Zakoïan, J.-M. (2010). *GARCH models: Structure, statistical inference and financial applications*. John Wiley & Sons.
5. Fuller, W. A. (1995). *Introduction to statistical time series* (2nd ed.). John Wiley & Sons.
6. Janacek, G., & Swift, L. (1993). *Time series: Forecasting, simulation, applications*. Ellis Horwood.
7. Tsay, R. S. (2010). *Analysis of financial time series* (3rd ed.). John Wiley & Sons.

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	**PO5**	PO6	**PO7**
CO1	H	H	M	H	M		H
CO2		H		L		L	M
CO3	H				H		
CO4	H	M		L			M
CO5	H	H	M		H	L	H
AVG	2.4	2	0.8	0.4	1.2	0.4	2

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance (1)

Financial Econometrics

Credit: **4**

Paper Code: **MSTR484C**

Course Outcomes (CO):
After successful completion of the course, the students will be able to:

CO1: Explain the concepts of risk-free and risky assets, financial contracts, options, and present valuation.
CO2: Understand and analyze self-financing portfolios, replication strategies, arbitrage opportunities, and market completeness.
CO3: Apply arbitrage principles and financial models such as the Harrison–Pliska theorem and Capital Asset Pricing Model (CAPM) to financial decision making.
CO4: Analyze and implement derivative pricing models including the Cox–Ross–Rubinstein binomial model and the Black–Scholes option pricing model.
CO5: Evaluate portfolio management strategies and measure financial risk using different techniques.

Course Content:

Module	Module Name	Topics	CO
I	Financial Assets and Valuation	Risk-free and risky assets. Financial contracts and options. Continuous compounding. Present valuation of cash flows. Risk and risk-neutral valuation.	**CO1**
II	Arbitrage and Portfolio Strategies	Self-financing portfolios in finite markets. Replication of contingent claims. Arbitrage opportunities. Market completeness and existence of arbitrage-free markets. Hedging strategies.	**CO2**
III	Asset Pricing Theory	Harrison–Pliska arbitrage theorem. Capital Asset Pricing Model (CAPM). Relationship between risk and return in financial markets.	**CO3**
IV	Derivative Pricing Models	Option pricing theory. Cox-Ross-Rubinstein binomial model. Black-Scholes option pricing model and applications.	**CO4**
V	Portfolio Risk Management	Portfolio management concepts. Diversification. Risk measurement. Value-at-Risk (VaR) and applications in financial risk management.	**CO5**

References:

1. Shiryaev, A. N. (1999). *Essentials of stochastic finance: Facts, models, and theory*. World Scientific.

2. Ross, S. M. (2011). *An elementary introduction to mathematical finance* (3rd ed.). Cambridge University Press.

3. Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997). *The econometrics of financial markets*. Princeton University Press.

4. Baxter, M., & Rennie, A. (1996). *Financial calculus: An introduction to derivative pricing*. Cambridge University Press.

5. Ross, M. (1999). *Introduction to mathematical finance: Options and other topics*. Cambridge University Press.

6. Bingham, N. H., & Kiesel, R. (2004). *Risk-neutral valuation: Pricing and hedging of financial derivatives* (2nd ed.). Springer.

7. Bawa, V. S., Brown, S. J., & Klein, R. W. (1979). *Estimation risk and optimal portfolio choice*. North-Holland

CO-PO mapping:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	H		M		L		
CO2	M		H		M		
CO3	M		H		M	L	
CO4	M		H	M	H		
CO5	M		M	M	H	M	M
AVG	**2.2**		**2.6**	**0.8**	**2.2**	**0.6**	**2**

***__H__ means High relevance (3), **M** means medium relevance (2), **L** means Low relevance (1)