LEARNING OUTCOME BASED CURRICULUM FRAMEWORK (LOCF) FOR POST GRADUATE PROGRAMS

(With effect from 2022-23)

M. Sc. - Statistics

Department of Statistics

LOYOLA COLLEGE (AUTONOMOUS),

CHENNAI – 600 034

PREFACE

Statistics is a discipline concerned with Collecting, Condensing, Analysing, and Drawing Inferences from Data for the purpose of providing intelligent and evidence-based solutions to issues concerning any human endeavour. Owing to its all-pervasive nature and applicability to almost all domains of knowledge, the presence of Statisticians is much required in any sector. The big-data boom has drawn the attention of youngsters who are finding statistics and the related area of data science as attractive choices for a rewarding career.

The learning outcome-based curriculum framework for a M.Sc. degree in Statistics is designed to prepare students in three important dimensions – Statistical Theory, Data Analysis Methodologies and the much-needed Computing skills – and prepares them for an exciting career. This focus enables the students to experience and enjoy the two-year program and get ready for a great future as academicians, statistical consultants and data-scientists in their chosen sectors. Students get exposure to applications of Statistics in related fields like actuarial, clinical and industrial statistics and get equipped with skills to handle big data in an information technology enabled environment.

The learning outcome-based curriculum framework provides the much-needed disciplinary knowledge, encourages self-learning, creates ethical consciousness, inculcates team spirit and empowers students with professional skills. The curriculum, teaching pedagogy and assessment methods are designed to reach appropriate cognitive levels as per BLOOM's Taxonomy. The OBE based evaluation methods will pave way for the assessment of cognitive levels of the students and evaluate the expected course outcome attainment

The multi-pronged approach, which is being followed in the Statistics Department of Loyola College, enables the students pursuing a post-graduate degree in Statistics to contribute to scientific advancement, industrial growth and national development through the skills that they acquire in the course of the two-year program.

CONTENTS

VIS ION, MISSION AND CORE VALUES OF LOYOLA COLLEGE

VISION:

- Towards holistic formation of youth, grounded in excellence, through accompaniment to serve the humanity

MISSION:

- To provide inclusive education through an integral and holistic formative pedagogy
- To promote skills that prepare them for the future
- To kindle in young minds the spirit of social and environmental justice with a blend of academic excellence and empathy
- To stimulate critical and conscientious scholarship leading to meaningful and innovative human capital

CORE VALUES:

- Cura Personalis
- Pursuit of Excellence
- Moral Rectitude
- Social Equity
- Fostering Solidarity
- Global Vision
- Spiritual Quotient

VIS ION AND MISSION OF DEPARTMENT OF STATISTICS

VISION:

- To form credible statisticians with innovative skills to aid scientific decision-making.

MISSION:

- To educate students with the all-pervasive and all-inclusive nature of Statistics
- To equip students with techniques needed for handling issues in different spheres of human activity
- To empower students with theoretical, applied and computing skills required for a rewarding professional life

PROGRAMME EDUCATIONAL OBJECTIVES (PEO's)
(School of Computational Sciences)

PEO 1	**Learning Environment And Life Long Learning** To access academic facilities in an environment of inclusiveness and inquisitiveness for effective and immersed learning throughout life to attain excellence in the chosen field of computational sciences.
PEO 2	**Globally Relevant Curriculum And Scientific Temperament** To think innovatively, analyze scientifically and take decisions appropriately, for handling contemporary global concerns through the knowledge earned in the computational sciences curriculum.
PEO 3	**Academic Excellence And Core Competency** To excel in modern computational techniques and compete in higher studies/career, for addressing contemporary challenging problems with ease.
PEO 4	**Skill Development And Entrepreneurship** To develop analytical, logical and critical problem-solving skills for executing professional work and become experts/entrepreneurs in the field of computational sciences.
PEO 5	**Environment And Sustainability** To identify real world problems concerning environment and other issues; and apply the expertise in the computational sciences, to face the challenges and provide sustainable solutions.
PEO 6	**Professionalism And Ethics With Social Responsibility** To equip themselves with the necessary competency towards professionalism in the computational sciences maintaining ethical standards in addressing the needs of industry and society.

PROGRAMME OUTCOMES (PO's)
(School of Computational Sciences)

PO1	**Disciplinary Knowledge, Information/Digital Literacy & Life-Long Learning:** To acquire scholarly knowledge for life-long learning of the respective discipline of computational sciences and demonstrate digital literacy.
PO2	**Critical, Analytical & Scientific Thinking In Problem-Solving** : To critically explore, scientifically analyze and develop solutions through various computational techniques for real time problems
PO3	**Globally Relevant Curriculum, Industry Requirements And Research Competence:** To acquire research competence and meet industry needs through a globally relevant curriculum
PO4	**Professionalism And Ethics:** To cultivate a promising work culture within ethical frameworks demonstrating exemplary professionalism.
PO5	**Teamwork And Effective Communications:** To manifest effective communication skills for constructive team work and progress as professionals in key positions in the respective domains.
PO6	**Empowerment With Empathy Towards Sustainable Social And Environmental Consciousness:** To realize social and environmental problems with empathy and contribute the computational expertise to face the challenges and provide sustainable solutions.
PO7	**Skill Development, Employability, Leadership And Entrepreneurship:** To develop expertise and professional skills for employment in the domain of computational sciences and emerge as leaders and entrepreneurs.

PROGRAMME SPECIFC OUTCOMES (PSO's)
Department of Statistics

PSO 1	**Disciplinary Knowledge & Digital Literacy** To become experts in devising scientific surveys, data-condensation, inferential procedures for large populations, designing statistical experiments, building predictive models and bring out the most useful information using statistical software packages.
PSO 2	**Self-Directed and Life-Long Learning** To get motivated and prepared towards a self-chosen direction by executing projects in a competitive environment for a life-long rewarding career path in Statistics.
PSO 3	**Sustainable Social and Environmental Consciousness** To gain and sustain consciousness about social and environmental concerns in a data-driven approach and provide solutions.
PSO 4	**Critical Thinking, Analytical Reasoning & Problem Solving** To critically assess real-life issues in various spheres of human endeavour, reason out and bring out viable solutions.
PSO 5	**Scientific Reasoning & Communication Skills** To handle professional matters scientifically supported by statistical analysis of data and effectively communicate the findings to stakeholders.
PSO 6	**Professionalism, Team Work & Ethics** To demonstrate professional competency in applying Statistical Theory and Methods founded on ethical principles enabling productive team-work.
PSO 7	**Skill Development for Leadership and Entrepreneurship** To cultivate the required skills needed for deploying appropriate statistical tools and techniques and establish oneself as a leading professional / entrepreneur.

Correlation Rubrics

High	Moderate	Low	No Correlation
3	2	1	0

Mapping of PEOs with Vision and Mission

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
Vision	3	3	3	3	3	3
Mission	3	3	3	3	3	3

Mapping of POs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	3	3	3	3	3	3
PO2	3	3	3	3	3	3
PO3	3	3	2	2	3	3
PO4	3	3	3	3	2	3
PO5	3	2	3	3	3	3
PO6	3	3	3	3	3	3
PO7	3	3	2	3	3	2

Mapping of PSOs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PSO1	3	3	3	3	3	3
PSO2	3	3	3	3	3	3
PSO3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3
PSO5	3	3	3	3	3	3
PSO6	3	3	3	3	3	2
PSO7	3	3	3	3	3	3

Mapping of PSOs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PSO1	3	3	3	3	3	3	3
PSO2	3	3	3	3	3	3	3
PSO3	3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3	3
PSO5	3	3	3	3	3	3	3
PSO6	3	3	3	3	3	3	3
PSO7	3	3	3	3	3	3	3

PART	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
MAJOR CORE (MC)	Advanced Distribution Theory (6h/6c) Applied Regression Analysis (5h/5c) Statistical Mathematics (6h/6c) Sampling Theory (5h/5c) Statistical Quality Control (4h/4c) Statistics Lab I (R) (4h/2c)	Estimation Theory (6h/5c) Testing Statistical Hypotheses (5h/5c) Categorical Data Analysis (5h/4c) Research Methodology (3h/2c) Statistics Lab II (R & Python) (4h/2c)	Multivariate Analysis (6h/6c) Advanced Stochastic Processes (6h/6c) Data Mining and Machine Learning (4h/4c) Statistics Lab III (Python) (4h/2c)	Advanced Experimental Design (6h/7c) Biostatistics & Survival Analysis (5h/6c) Statistics Lab IV (SAS) (4h/2c)
MAJOR ELECTIVE (ME)	--------	Time-Series Modelling (4h/2c) Reliability Theory (4h/2c) Probability Theory (4h/2c)	Advanced Operations Research (4h/2c) Actuarial Statistics (4h/2c) Spatial Statistics (4h/2c)	---------
INTER-DISCIPLINARY (ID)	--------	-------	Data Visualization & Mat (T + L -4h/2c + 2h/1c)	---------
SELF-STUDY / ONLINE COURSES (SSC)	--------	Non-Parametric Methods / SQL/ Six-Sigma / Epidemiology / Econometrics / Financial Mathematics (2h/2c) #	--------	--------
SOFT SKILLS (SS)	--------	Subject offered by School of Human Excellence (2h/1c) #	Subject offered by School of Human Excellence (2h/1c) #	--------
CROSS-DISCIPLINARY	--------	Subject offered by other Schools (3h/1c)	--------	--------

COURSES (CD)				
VALUE – ADDED COURSES (VA)	--------	--------	Subject offered by any Department (2h/1c)#	--------
SUMMER INTERNSHIP (SI)	--------	Summer 3 to 4 weeks (1c)#	--------	--------
SERVICE LEARNING (SL)	--------	--------	LEAP (120h/1c)#	--------
PROJECT	--------	--------	--------	Project & Dissertation (15h/5c)
TOTAL	(30H/28C)	(30H/21C)+(2H/1C)+(4W/1C)+(2H/2C)	(30H/23C)+(4h/2c)+(120H/1C)	(30H/20C)
CREDITS ALLOCATED	**28**	**23 + 2 (Additional)**	**26**	**20**

PG RESTRUCTURING – 2022 (2022-23 Batch onwards) M.Sc. Statistics

LOYOLA COLLEGE (AUTONOMOUS), CHENNAI

DEPARTMENT OF STATISTICS

(2022 – Restructured Curriculum)

M.Sc. STATISTICS – OVERALL COURSE STRUCTURE

I SEMESTER						
Sem.	**Sub. Code**	**Course Title**	**T/L/P**	**Category***	**Hours**	**Credit**
I	PST1MC01	Advanced Distribution Theory	T	MC	6	6
I	PST1MC02	Applied Regression Analysis	T	MC	5	5
I	PST1MC03	Statistical Mathematics	T	MC	6	6
I	PST1MC04	Sampling Theory	T	MC	5	5
I	PST1MC05	Statistical Quality Control	T	MC	4	4
I	PST1MC06	Statistics Lab I [R]	L	MC	4	2
II SEMESTER						
II	PST2MC01	Estimation Theory	T	MC	6	5
II	PST2MC02	Testing Statistical Hypothesis	T	MC	5	5
II	PST2MC03	Categorical Data Analysis	T	MC	5	4
II	PST2MC04	Research Methodology	T	MC	3	2
II	PST2MC05	Statistics Lab II [R & PYTHON]	L	MC	4	2
II	PST2ME01	Time Series Modelling	T	ME	4	2
II	PST2ME02	Reliability Theory	T	ME	4	2
II	PST2ME03	Probability Theory	T	ME	4	2
II	PST2MO01 PST2MO02 PST2MO03 PST2MO04 PST2MO05 PST2MO06	Non-Parametric Methods [OR] SQL[OR] Six-Sigma [OR] Epidemiology [OR] Econometrics [OR] Financial Mathematics	T	MO	2	2
II	PHE2SS01	Soft Skill - I	T	SS	2	1
II	PST2CD01	Statistical Analysis [to other Schools]	T	CD	3	1
II	PST2SI01	Summer Internship	T	SI	3 to 4 Week	1

III SEMESTER						
III	PST3MC01	Multivariate Analysis	T	MC	6	6
III	PST3MC02	Advanced Stochastic Processes	T	MC	6	6
III	PST3MC03 –	Data Mining and Machine Learning	T	MC	4	4
III	PST3MC04	Statistics Lab III [PYTHON]	L	MC	4	2
III	PST3ME01	Advanced Operations Research	T	ME	4	2
III	PST3ME02	Actuarial Statistics	T	ME	4	2
III	PST3ME03	Spatial Statistics	T	ME	4	2
III	PST3ID01	Data Visualization and MATLAB Theory	T	ID	4	2
III	PST3ID02	Data Visualization and MATLAB Lab	L	ID	2	[1]
III	PHE3SS02	Soft Skill – II	T	SS	2	1
III	PST3VA01	Applied Statistics using SPSS –LAB [Open to All Schools]	L	VA	2	1
III		Leap	T	SL	120	1
IV SEMESTER						
IV	PST4MC01	Advanced Experimental Design	T	MC	6	7
IV	PST4MC02	Biostatistics and Survival Analysis	T	MC	5	6
IV	PST4MC03	Statistics Lab IV [SAS]	L	MC	4	2
IV	PST4PD01	Project & Dissertation	P	PD	15	5

- **MC**-Major Core, **ME**–Major Elective, **ID**–Interdisciplinary course, **VA**-Value added Course, **SSC** – Self Study Course, **SS** – Soft Skills, **SI** – Summer internship, **PD** – Project and Dissertation

Semester I

COURSE DESCRIPTOR

Course Code	**PST1MCO1**
Course Title	**ADVANCED DISTRIBUTION THEORY**
Credits	**06**
Hours/Week	**06**
Category	**MAJOR CORE (MC) – THEORY**
Semester	**I**
Regulation	**2022**

Course Overview:

- A probability distribution is a statistical function that describes all the possible values and likelihoods that a random variable can take within a given range.
- Our everyday lives, as well as economic and business activities, are full of uncertainties and so probability and distribution theory offer useful techniques for quantifying these uncertainties.
- Probability distributions are fundamental concepts in statistics. They are used both on a theoretical level and a practical level.
- This course helps the students to understand the fundamental concepts of distribution theory.
- This course helps the students to apply the life distributions to real time data.

Course Objective:

- To present the general theory of statistical distributions as well as the standard distributions found in statistical practice
- To impart necessary knowledge about theoretical aspects of two and multi-dimensional random variables and their distributions.
- To apply selected probability distributions to solve problems.

Prerequisites	Basic Knowledge of Mathematics(Calculus, Matrix algebra), Probability theory.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Discrete distributions**:** Power Series, Exponential family and Non Regular family of distributions	**14**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Multivariate Distribution: Bivariate Binomial distribution, Trinomial and Bivariate Poisson distribution, their properties, Multinomial Bivariate Normal and Bivariate exponential (Marshall and Olkin) distributions - Important properties.	**14**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Non-central distributions: Non-central Chi-square, t and F distributions and their properties, Compound distributions and Mixtures of distributions	**14**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Order statistics, their distributions and properties - Distribution of range and mid range - Extreme values and their asymptotic distributions (concepts only).	**14**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Quadratic forms in Normal variates **:** Properties of idempotent matrices- Quadratic forms- Definiteness of a quadratic form-Generalized inverse (elementary ideas only) - Necessary and Sufficient condition for a Quadratic form to be distributed as a Chi-square distribution, Cochran's theorem.	**14**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Hogg, R.V. and Craig, A.T.(2002). Introduction to Mathematical Statistics. Pearson Education, Asia.
2. Johnson, N.L. and Kotz, S.(2004). Distributions in Statistics. Vol. 1 – 4. John Wiley and Sons, New York.
3. Johnson,N.L., Kotz,S and Balakrishnan,N. (2004). Discrete Multivariate Distributions. John Wiley and Sons, New York.
4. Albert W. Marshall, Ingram Olkin (2007) - Life Distributions: Structure of Nonparametric, Semi parametric, and Parametric Families, Springer Series in Statistics

SUGGESTED READINGS

1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (2004). Continuous Univariate Distribution. Vol. 1 John Wiley and Sons,(Asia) Pte.Ltd. Singapore.
2. Johnson, N.L., Kotz, S. and Balakrishnan ,N(2004). Continuous Univariate Distributions Vol. 2. John Wiley and Sons,(Asia) Pte.Ltd. Singapore
3. Johnson, N.L., Kotz, S.and Kemp, A.W (1992). Univariate Discrete Distributions . John Wiley and Sons, New York.
4. Rohatgi, V.K. and Saleh, A.K.Md.E (2002). Introduction to Probability and Statistics, Pearson Education, Asia

WEB SOURCES

1. https://nptel.ac.in/courses/111/104/111104032/
2. https://onlinecourses.swayam2.ac.in/cec21_ma02/preview
3. https://www.coursera.org/courses?query=probability%20distribution

COURSE OUTCOMES (COs)

PST1MC01 - ADVANCED DISTRIBUTION THEORY (MC)		Cognitive Levels
CO 1	To describe the most common discrete and continuous probability distributions and their real life applications and to calculate probabilities by applying probability laws and theoretical results.	**K1, K2**
CO 2	To describe the bivariate distributions and to demonstrate with transformation of univariate and multivariate densities. The Distributions help to understand the nature of data and to perform appropriate analysis.	**K3**
CO 3	To Apply compound, Truncated, Mixture and Non-Central distributions to real time data.	**K4**
CO 4	To establish the quadratic forms in Normal variates and to describe the	**K5**
	distinguishing features of various probability distributions	
CO 5	To identify an appropriate probability distribution for a given discrete or continuous random variable and use its properties to calculate probabilities and to diagnose the role of Empirical distribution function and life distributions in the data analysis.	**K6**

COURSE DESCRIPTOR

Course Code	**PST1MC02**
Course Title	**APPLIED REGRESSION ANALYSIS**
Credits	**05**
Hours/Week	**05**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**I**
Regulation	**2022**

Course Overview

- Regression analysis is used to build statistical models of the relationships between variables that can be used for enhanced understanding of the causes of a phenomenon and, when it works, for prediction of future outcomes.
- The course provides foundational methods and ideas for many of the techniques used in data mining and the ultimately support better decision making.
- The course premise is that successful applications of regression require understanding of both the practical problem and the underlying statistical theory.
- The course focuses primarily on multiple regression models which includes weighted least square, Polynomial, ARIMA and Logistic regressions
- This course is supplemented with computer labs involving interactive data analysis using statistical softwares.

Course Objective

- Learn how to apply linear regression models in practice: identify situation where linear regression is appropriate; build and fit linear regression models with software; interpret estimates and diagnostic statistics; produce exploratory graphs.
- Learn about the theory underlying point estimation, hypothesis and confidence intervals for linear regression models.
- Students will obtain a good foundation in using regression-based statistical models to analyze real and simulated data using different Software's, and will learn how to interpret and critically evaluate the results of those analyses

Prerequisites	Basic Statistics, Testing Hypothesis, ANOVA, Matrix and Linear algebra.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Simple and Multiple Linear Regression. Estimation of model parameters, Hypothesis testing, Confidence intervals, Prediction, Residual analysis, PRESS statistic, Lack of fit.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Polynomial regression model in one variable – Piece wise polynomial fitting (Splines), Non-parametric regression, polynomial regression in two variables, Indicator variables,	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Variance stabilizing transformations, transformations to Linearizing a model, power transformation of dependent and independent variables , bias estimation, Generalized and weighted least squares	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Multicollinearity problem, Diagnostic, Methods for dealing with multicollinearity, Model building problem, Variable selection – Stepwise regression methods - Model Validation.	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Auto correlation, Partial Auto Correlation, Stationarity, Unit Root Test, Non Stationarity in Variance, Random Walk, Random Walk with Drift, Auto Regressive Model, Moving Average Process, ARIMA – Determining Model, Estimation and Forecasting.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Montgomery,D.C., Peck E.A, and Vining G.G.(2003). Introduction to Linear Regression Analysis. John Wiley and Sons, Inc.NY.
2. Ngai Hang Chan(2002). Time Series Applications to Finance, Wiley Series

SUGGESTED READINGS

1. Draper, N. R. & Smith, H.(1998). Applied Regression Analysis, 3rd Ed. (John Wiley).

WEB SOURCES

1. https://www.csulb.edu/~msaintg/ppa696/696regmx.htm
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3049417/
3. http://ordination.okstate.edu/MULTIPLE.htm
4. https://iopscience.iop.org/article/10.1088/1742-6596/949/1/012009
5. https://nptel.ac.in/content/storage2/courses/111104074/Module9/Lecture28.pdf
6. https://online.stat.psu.edu/stat462/node/158/
7. https://stats.oarc.ucla.edu/r/dae/probit-regression/
8. https://www.econometrics-with-r.org/11-2-palr.html
9. https://online.stat.psu.edu/stat462/node/89/
10. https://sscc.wisc.edu/sscc/pubs/RegressionDiagnostics.html

COURSE OUTCOMES (COs)

PST1MC02 - APPLIED REGRESSION ANALYSIS (MC)		Cognitive Levels
CO 1	To **expose** and **understand** the concepts that underly modern methods of linear regression.	**K1, K2**
CO 2	To **apply** theories and methods to build statistical models of the relationships between variables that can be used for prediction of future outcomes.	**K3**
CO 3	To **Analyses** and **distinguish** models, methods, analysis tools in regression analysis and choose the best model to address research questions and fit into different data structure.	**K4**
CO 4	To **integrate** analytical skills and knowledge from regression modelling, computation, and interpretation of results through a data and team project.	**K5**
CO 5	To **investigate, develop** and **evaluate** related regression techniques and model building process using real life data and statistical software.	**K6**

COURSE DESCRIPTOR

Course Code	**PST1MC03**
Course Title	**STATISTICAL MATHEMATICS**
Credits	**06**
Hours/Week	**06**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**I**
Regulation	**2022**

Course Overview

- Statistical Mathematics deals with the necessary mathematical foundation for post graduate studies in Statistics.
- It gives an exposure to the students in the mathematical pre-requisites of Statistics.
- It deals with some concepts of Real Analysis which are fundamentals of Statistics
- It also presents some concepts of Linear Algebra which are pre-requisites for Statistics.

Course Objective

- To impart knowledge on various concepts in Real Analysis and Linear Algebra which are used in Statistics.
- To understand several theorems in Real Analysis and Linear Algebra which have applications in Statistics.
- To use deductive and inductive reasoning for proving theorems and results.
- To develop logical thinking for solving relevant mathematical and statistical problems.
- To apply theorems and results in finding solutions to mathematical and statistical problems..

Prerequisites	Basic Knowledge of Mathematics.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Real Sequences and Series: Boundedness, monotonicity, convergence. Operations on sequences –Results on limit superior and limit inferior of a sequence - Infinite series – convergence – tests for convergence.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Real functions: Boundedness, monotonicity, continuity. Differentiable functions – Extreme Values – Intermediate forms.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Riemann Integrals**:** Riemann Integrals, Properties – Fundamental theorems – Basic results - Improper integrals – Tests for convergence – Riemann-Stieltjes integrals.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Vector Spaces and Linear Mappings**:** Euclidean Spaces – Linear Independence / Dependence – Basis – Dimension – Linear Transformations - Inner products – Orthogonality.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Determinants and Quadratic forms: Determinants Eigen values and vectors – Minimal Polynomial – Bilinear forms - Quadratic forms – Diagonal forms – Decompositions - Matrix square root. Gram-Schmidt Orthogonalization (Notion only)	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Bellman, R. (1974). Introduction to Matrix Analysis, Tata-McGraw-Hill Publishing Co Ltd. Unit – V : Sections 3.4 to 3.7, 6.5
2. Franz, E. Hohn (1973). Elementary Matrix Algebra, Amerind Publishing Co. Pvt. Ltd.
   Unit IV : Sections 5.9 to 5.13, 5.17, 5.19, 5.22, 6.4, 7.2, 7.3, 7.4
   Unit V : Sections 8.1 to 8.4
3. Seymour Lipschutz & Marc Lars Lipson (2016). Theory and Problems of Linear Algebra, Third Edition, McGraw Hill Education, New Delhi.
   Unit – IV : Sections 5.1 to 5.6
   Unit – V : Sections 8.1 to 8.12, Sections 9.7, 9.8, Section 12.2
4. Shanti Narayan and Raisinghania, M.D. (2016). Elements of Real Analysis, Revised Edition, S. Chand, New Delhi.
   Unit – I : Section 5.13, 5.14
   Unit - II : Sections 12.1 to 12.9
   Unit – III : Sections 14.1 to 14.6
5. Somasundaram, D. and Choudhry, B. (1999). A First Course in Mathematical Analysis, Narosa Publishing house, New Delhi.
   Unit – I : Sections 2.1, 2.3 to 2.8, 3.1 to 3.4, 3.6
   Unit – II : Sections 4.2, 4.3, 4.4, 4.5, 7.1, 7.3, 9.2
   Unit – III : Sections 8.1, 8.3, 8.4, 8.5

SUGGESTED READINGS

1. Burkill, J.C. (1962). A First Course in Mathematical Analysis, Cambridge University Press.
2. Chakrabarti, A. (2008). A First Course in Linear Algebra, Vijay Nicole Imprints Pvt. Ltd.
3. Goldberg, R.R. (1970). Methods of Real Analysis, Oxford & IBH Publishers.
4. Hadley, G. (1987). Linear Algebra, Narosa Publishing House.

WEB SOURCES

1. **https://www.khanacademy.org/math/linear-algebra**
2. **https://www.coursera.org/courses?query=linear%20algebra**
3. https://bit.ly/3sQvcFq
4. **https://en.wikipedia.org/wiki/Linear_algebra**
5. https://bit.ly/3sW7ojq
6. https://bit.ly/3H7hp2b
7. **https://www.youtube.com/watch?v=gJ1pYz1k0qM**
8. https://amzn.to/3v3AxvT

COURSE OUTCOMES (COs)

PST1MC03 - STATISTICAL MATHEMATICS **(MC)**		**Cognitive Levels**
CO 1	To **understand** the concepts of Real Analysis and Linear Algebra which are mathematical foundation for post graduate studies in Statistics.	**K1, K2**
CO 2	To **solve** problems and to **demonstrate** with examples in real sequences, infinite series, real functions, Riemann integral, linear transformations, Eigen values and Eigen vectors, and quadratic forms.	**K3**
CO 3	To **analyse** and **test** for convergence of real sequences, infinite series, and improper integrals.	**K4**
CO 4	To **draw** connections among theorems for justifying properties and results.	**K5**
CO 5	To **examine** the nature of sequences, infinite series, improper integrals, vectors and quadratic forms and **develop** new results	**K6**

COURSE DESCRIPTOR

Course Code	**PST1MC04**
Course Title	**SAMPLING THEORY**
Credits	**05**
Hours/Week	**05**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**I**
Regulation	**2022**

Course Overview

- Sampling Theory deals with various Sample Techniques useful in survey methodolgy.
- This course deals with the construction of valid Sampling Designs corresponding to various sampling techniques.
- It describes the unit drawing mechanism for each Sampling design and verifies if the mechanism implements the Design.
- It presents different methods of selecting a sample from a population and gives a comparison among the methods.
- It tells about how to obtain good estimators from the samples so that the estimated value can be used as an approximate value for the unknown population characteristics which are of interest to us.

Course Objective

- To impart knowledge on various sampling techniques useful in survey methodology.
- To train students in constructing valid sampling designs and to propose unit drawing mechanism for implementing the design.
- To explore various sampling techniques and understand their merits and drawbacks.
- To provide appropriate estimates of the required information.
- To provide methods for overcoming the problem of non-response.

Prerequisites	Basic Knowledge of Statistics, Mathematics, and Computers.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Introduction to the theory of sampling: sampling designs – Construction of fixed size and varying size sampling designs - estimation procedures –Results on inclusion indicators and inclusion probabilities - properties of estimators – SRSWOR – properties of SRSWOR – optimal properties of the sample mean.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Sampling with varying probability: procedures for PPS selection –Midzuno Sampling Design - Desraj ordered and Murthy's unordered estimators– Random Group Method - HT estimator – optimal properties of HT estimators – estimation of variance of HTE	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Stratified sampling: estimation of the population mean – allocation problems. Systematic sampling – Methods for populations with linear trend – Yates' Corrected Estimator - Comparison with SRSWOR and stratified sampling for standard populations.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Ratio estimation - approximation to bias and MSE – Hartley-Ross Unbiased Ratio type Estimator - regression estimation - approximation to bias and MSE – Double sampling for ratio and regression – Hansen-Hurwitz Estimator - Multi stage sampling: Multi phase sampling - Cluster sampling and multistage sampling under SRS methods.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Non-response: effects of non-response, Warner' model, Simmons randomized response technique – Planning and organization of large scale surveys -– Incomplete Surveys – Call Back Techniques - Adaptive Sampling – Estimation of Distribution Function.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Cochran, W.G. (2000). Sampling Techniques, John Wiley and Sons, New York.
2. Sampath, S. (2005). Sampling Theory and Methods, Narosa Publishing House, New Delhi.

SUGGESTED READINGS

1. Changbao Wu (2020). Sampling Theory and practice, Springer.
2. Deming, W.E. (2000). Some Theory of Sampling. John Wiley and Sons, New York.
3. Des Raj and Chandok, P. (1998). Sampling Theory. Narosa Publishing House, New Delhi.
4. Donald P. Warwick (1975). The sample survey: theory and practice. McGraw-Hill.
5. Murthy, M.N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
6. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (2000). Sampling theory of surveys with applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

WEB SOURCES

1. https://bit.ly/3sP4rSZ
2. https://bit.ly/34kq588
3. https://bit.ly/361RLiQ
4. https://bit.ly/3MuBwLN
5. https://bit.ly/3KpHPhK

COURSE OUTCOMES (COs)

PST1MC04 - SAMPLING THEORY (MC)		Cognitive Levels
CO 1	To **understand** and **remember** the procedures for different sampling techniques.	**K1, K2**
CO 2	To **draw** samples from different populations by **applying** different sampling techniques and **obtain** estimates of unknown population parameters.	**K3**
CO 3	To **analyse** and **compare** the unbiasedness and efficiencies of estimates under different sampling techniques.	**K4**
CO 4	To evaluate and justify the merits and limitations of different sampling techniques.	**K5**
CO 5	To develop a questionnaire, organize a sample survey by implementing different sampling techniques and estimate population characteristics.	**K6**

COURSE DESCRIPTER

Course Code	**PST1MC05**
Course Title	**STATISTICAL QUALITY CONTROL**
Credits	**4**
Hours/Week	**4**
Category	**MAJOR CORE (MC) – THEORY**
Semester	**I**
Regulation	**2022**

Course Overview:

- To study the overview of quality control methodologies and predictive statistical analysis.
- To understand the concepts of various control charts for quality control.

Course Objective:

- To realize the importance of quality and quality improvement techniques.
- Design, use and interpret CUSUM and EWMA control chart.
- Perform analysis of process capability.
- Describe Acceptance sampling plan for variables and attributes.

Prerequisites	Basic Knowledge of Statistics and Mathematics

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**CO's**	**COGNITIVE LEVEL**
I	Introduction to Quality and Quality Improvement; Meaning and Scope of Statistical process control (SPC), Shewart Control Charts for X-bar, R, np, p, c charts. and their uses. OC and ARL of control charts.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	control charts based on coefficient of Variation. extreme values, moving averages, Exponential weighted moving average control chart, modified control charts CUSUM procedures, use of V mask, Multivariate control charts.	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Process capability, C_p, C_{pk}, C_{pm} - tolerance limits, Modified Control Charts - beta content and beta expectation, Normal theory and nonparametric approaches.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Acceptance sampling plans for attribute inspection; single, double - OC, ASN, AOQ, AOQL and ATI curves, and multiple sampling plans, chain sampling plan- Continuous Sampling plan – CSP-1, CSP-2, CSP-3.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Acceptance sampling variables for process parameter – Sequential plans for process parameter (σ known and unknown) – Sampling variables for proportion non-conforming.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Book:

1. Duncan A.J. (2010). Quality Control and Industrial Statistics, 2nd edition, Homewood.
2. Grant, E.L. and Leaven worth, R.S. (2004). Statistical Quality Control, 2nd edition, Mc-Graw Hill Book Co.
3. Montgomery D.C. (2007). Introduction to Statistical Quality Control, John Wiley
4. Shilling, E.G. and Neubauer D.V. (2010). Acceptance Sampling in Quality Control, second edition, A Chapman & Hall book.
5. Juran, J.M. and Gryana, F.M. (2008).Quality planning and analysis, Tata Mc-Graw Hill.

Suggested Readings:

1. Wetherill, G.B. (1977) - Sampling Inspection and Quality Control, Halsted Press, N.Y.Ott, E.R.- Process Quality Control, Mc-Graw Hill
2. Gupta, S, G,, Kapoor, V.K. (2014). Fundamentals of Applied Statistics, 4th edition, Sultan Chand & co.

Web Resources:

1. https://bit.ly/3BGU7PH
2. https://bit.ly/33FTWYl
3. https://bit.ly/3LQrmVv
4. https://bit.ly/3IbyaLa

Course Outcomes (CO's)

PST1MC05 – STATISTICAL QUALITY CONTROL (MC)		Cognitive Level
CO1	Recall and Understand the history and requirements for effective quality systems in Industry.	K1, K2
CO2	Sketch the various control charts and Identify if the process is in control and process is capable.	K3
CO3	Apply and Analyze Process monitoring techniques.	K4
CO4	Design and prescribe various acceptance sampling plans for quality assurance	K5
CO5	Compare various Process monitoring techniques and discuss how procedures for statistical quality control can be implemented and contribute to development in industrial organizations	K6

COURSE DESCRIPTOR

Course Code	**PST1MC06**
Course Title	**STATISTICS LAB – I (R)**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR CORE (MC) – LAB**
Semester	**I**
Regulation	**2022**

Course Overview

- This course enables students to gain knowledge in R for Statistical Data Analysis
- Data preparation and data management using R Programming
- Simulation of data and fitting of distribution through user defined functions
- Construction of Linear Regression model and evaluation of model assumption in R
- Control charts for detection of assignable cause and measure process capability

Course Objectives

- To understand the basics of R programming for data management
- To write user defined function in R for simulation of random data from a specific distribution.
- To determine the best fit among a set of potential candidate distributions.
- To construct linear regression model for prediction and assess model assumptions and take necessary corrective actions.
- To monitor the process quality characteristics through control charts and process capability measures.

Prerequisites	Basic computer literacy and programming knowledge.

SYLLABUS				
UNIT	CONTENT	Hours	Cos	C.L.
I	Data Management in R: Data Types in R – Vector, Matrix, Array, Data Frame and List- Matrix - Determinant, Inverse, Eigen Values and Eigen Vectors, Linear Dependency - Importing and Exporting Datasets in R - - Variable creation and Conditional Subsetting -Aggregating Dataset -Merging Datasets – Inner Join, Outer Join, Left Join, Right Join -Loops : For Loop - While Loop and Repeat Loop -User defined function with input arguments.	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Simulation of Random Sample from a specific distribution: Random sample based on SRWR, SRSWOR, Sequential sampling - Stratified Random sampling, Cluster sampling. PPS sampling - Horwitz – Thompsonn Estimator , Hansen – Horwitz Estimator , Desraj Ordered Estimator - Generate Random Sample from Binomial, Poisson and Negative Binomial Distribution - Generate Random Sample from Exponential and Normal Distribution	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Fitting of Distribution: Fitting of Binomial, Poisson and Negative Binomial distribution - Fitting of Truncated Binomial Distribution - Fitting of Truncated Poisson Distribution - Fitting of Mixture of Geometric and Poisson - Fitting of Mixture of Two Poisson	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Regression Analysis: Fitting of multiple linear model using model selection procedure. - Testing for Overall Model fit and Individual Regression Coefficients - Determining R-Square, Adjusted R-Square, MAE and MAPE - Study of Interaction Effects and detection of outliers - Testing for Multicollinearity using VIF and Conditional Index - Transformation and Combining Variables to deal Multicollinearity - Residual Analysis – Testing for Normality of Residuals, Transformation	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Statistical Process Control**:** Control Chart for Attributes – p-chart, np- chart, c-chart, u-chart. Control charts for variables – X -chart, R-chart, S-chart. - Process capability computations. - Special charts – Moving range chart, CUSUM chart, EWMA control chart. - OC Curves for various charts. - Single Sampling Plan – OC curve, AOQ curve, ATI curve. - Double Sampling Plan – OC curve, ASN curve, AOQ curve, ATI curve	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. R, Robert I. Kabacoff (2015), R in Action: Data Analysis and Graphics.
2. Hadley Wickham, Garrett Grolemund (2016), R for Data Science: Import, Tidy, Transform, Visualize, and Model Data, , Wiley Publication.

Suggested Readings

1. Peter Dalgaard (2008), Introductory Statistics with R,
2. Måns Thulin (2021), Modern Statistics with R: From wrangling and exploring data
3. Daniel Navarro (2013), Learning Statistics with R,

Web Resources

1. https://www.statmethods.net/r-tutorial/index.html
2. https://www.guru99.com/r-tutorial.html
3. https://www.listendata.com/p/r-programming-tutorials.html
4. https://data-flair.training/blogs/r-tutorials-home/

Course Outcomes (CO's)

PST1MC06 - STATISTICS LAB – I (MC)		Cognitive Level
CO 1	To slide and dice datasets into required format for analysis purpose.	**KI, K2**
CO 2	To generate random samples from specific distributions using user defined functions.	**K3**
CO 3	To fit discrete / continuous distributions and determine goodness of fit	**K4**
CO 4	To fit multiple linear regression model for predicting and to identify the significant variables	**K5**
CO 5	To construct statistical control charts and determine the presence /absence of assignable cause and to measure process capability.	**K6**

II SEMESTER

COURSE DESCRIPTOR

Course Code	**PST2MC01**
Course Title	**ESTIMATION THEORY**
Credits	**05**
Hours/Week	**06**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

- This course provides a strong theoretical foundation to deal with real life situations in estimating the parameters of the population.
- It emphasizes on the properties of a good estimator.
- This course also deals with the different estimation methods.
- It deals with confidence intervals for parameters.
- Bayes' estimation, M-estimation, Jackknife and Bootstrap methods are discussed.

Course Objective:

- To understand the basic concepts of point and interval estimation.
- To examine the properties of a good estimator.
- To construct various inequalities and confidence intervals related to estimators.
- To apply different estimating procedures to obtain estimators for the parameters of different populations.
- To analyse the asymptotic behaviour of estimators.

Prerequisites:	Mathematical Knowledge

SYLLABUS

UNIT	CONTENT	HOURS	Cos	COGNITIVE LEVEL
I	Problem of Point estimation-Desirable properties of a good estimator- Unbiasedness, Consistency, Sufficiency and Efficiency - Examples. UMVUE - Properties –BLUE - Examples. Cramer-Rao inequality - Chapman-Robbins inequality (single parameter case only) – Bhattacharya inequality (single parameter case only) - Invariant and Equivariant estimation (concepts only).	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Sufficient statistic for a parameter - Properties of sufficient statistic. Fisher-Neyman Factorization Theorem (Proof in the discrete case only) - Rao-Blackwell Theorem - Examples. Exponential family of distributions-Minimal sufficiency. Ancillary statistics - Pitman family of distributions.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Completeness and bounded completeness. Lehman-Scheffe Theorem - Basu's Theorem – Examples. Median and Modal unbiased estimation.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Methods of Estimation – Moments - Maximum Likelihood - Minimum Chi-square – Examples. Properties of MLE. CAN and BAN estimation and their properties. Interval estimation - Pivot method of construction - Shortest confidence intervals and their construction (minimum average width). Construction of shortest confidence intervals in large samples.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Bayesian procedure - Prior and Posterior distributions - Bayesian point estimation - Bayesian interval estimation. Minimax estimation. M-estimation - Jackknife and Bootstrap methods.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5,K6

TEXT BOOKS

1. Kale B.K.(2005). A first course on parametric inference, Narosa Publishing House
2. Kendall M.G. and Stuart A.(1967). The Advanced Theory of Statistics.Vol.2.Inference and Relationship. Hafner Publishing Co., New York.
3. Lehmann E.L. and Casella G.(1998).Theory of Point estimation. Springer-Verlag.

SUGGESTED READINGS

1. Rohatgi V.K.(2003).Statistical Inference , Dover Publications , New York.
2. Zacks. S., (1981). Parametric statistical Inference , John-Wiley , New York.

WEB SOURCES

1. https://www.britannica.com
2. https://courses.grainger.illinoise.edu
3. https://www.researchgate,net
4. https://www.edx.org
5. https://www.maths.qmul.ac,uk

COURSE OUTCOMES (COs)

PST2MC01 - ESTIMATION THEORY (MC)		Cognitive Levels
CO 1	To **define** statistic, unbiasedness, consistency, sufficiency and efficiency for estimators and **explain** different estimation methods with applications.	**K1, K2**
CO 2	To **obtain** minimum variance unbiased estimators for the parameters in different populations.	**K3**
CO 3	To **analyse** the different types of estimation methods in finding the best estimator.	**K4**
CO 4	To **decide** the best estimating procedure with regard to the minimum variance of the estimators.	**K5**
CO 5	To develop inequalities and confidence intervals related to estimators.	**K6**

COURSE DESCRIPTOR

Course Code	**PST2MC02**
Course Title	**TESTING STATISTICAL HYPOTHESES**
Credits	**05**
Hours/Week	**05**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

- This course imparts basic ideas about testing procedures.
- Testing of Hypotheses focuses on solving practical statistical problems.
- This course is framed to assist the researchers of various other fields.
- Testing of Hypothesis contains essential theories to provide guidance in quality management.
- The course covers topics which is mandatory to crack competitive exams related to Statistics.

Course Objective:

- To introduce the concepts of hypothesis testing.
- To differentiate between large and small samples and apply apt testing procedures.
- To explain various non-parametric tests and its applications.
- To impart knowledge on techniques for testing of hypotheses towards decision support based on sample characteristics.
- To illustrate the real-life applications of testing problems and procedures.

Prerequisites:	Estimation Theory concepts

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Statistical hypotheses, Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, Most Powerful Tests, Uniformly Most Powerful Tests for distributions with Monotone Likelihood Ratio, Generalization of the fundamental lemma (without proof).	13	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Two-sided hypotheses, Unbiasedness for hypothesis testing. Applications to one-parameter exponential family. Similarity and completeness. UMP unbiased tests for multiparameter exponential family and applications.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Symmetry and invariance, maximal invariants, most powerful invariant tests, unbiasedness and invariance.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Likelihood ratio tests, large sample properties, asymptotic distribution of LRT statistic for simple null hypothesis. SPRT and its applications.	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Non-parametric tests: Chi-Square Goodness of fit test, Kolmogorov-Smirnov test (Two Sample Test), Wald-Wolfowitz run test, Median test, Mann-Whitney U test, Kruskal-Walli's test and Friedmann test.	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Kale, B.K.(2005). A first course on parametric inference, Narosa publishing house, New Delhi.
2. Lehmann, E.L. (1986) Testing Statistical Hypotheses, John Wiley and sons, NY.
3. Gupta S.C and Kapoor V.K. (2002). Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
4. Hogg R.V and Craig A.T. (2002). Introduction to Mathematical Statistics, PearsonEducation (P.Ltd, Singapore).
5. Beaumont.G.P. (1980). Intermediate Mathematical Statistics, Chapman and Hall. NewYork.
6. Gibbons J. D. (1971). Non-parametric Statistical Inference, McGraw-Hill KogakushaLtd., New Delhi.
7. Mood A. M, Graybill F. A and Boes D. C. (1983) Introduction to the Theory of Statistics, McGraw-Hill, New Delhi.

SUGGESTED READINGS

1. Rohatgi, V.K. and Saleh, E.A.K. Md.(2002)An Introduction to Probability and Statistics,John Wiley and sons, NY.
2. Kendall, M.G. and Stuart, A. (1967) The Advanced theory of Statistics, Vol-2, Hafner publishing co., New York.
3. Sanjay Arora and Bansi Lal (1989). New mathematical Statistics, Satya Prakashan, NewDelhi.
4. Goon A.M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I & II,8th Edn. The World Press, Kolkata.
5. Miller, I and Miller, M. (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
6. Hogg, Tanis, Rao. (2009). Probability and Statistical Inference.7th Edition. Pearson.
7. Milton J. S. and Arnold J. C. (2017). Introduction to Probability and statistics, 4th Edition,Tata McGraw hill Publication.

WEB SOURCES

1. https://www.khanacademy.org
2. https://www.nedarc.org
3. http://egyankosh.ac.in/

COURSE OUTCOMES (COs)

PST2MC02 - Testing Statistical Hypotheses (MC)		Cognitive Levels
CO 1	Recall the fundamental concepts of inferential statistics	**K1, K2**
CO 2	Explain the concepts and appropriate conditions needed for framing a test	**K3**
CO 3	Problem solving based on hypotheses validation	**K4**
CO 4	Exploring real life problems and modelling it	**K5**
CO 5	Evaluate the inferences made out of modelling	**K6**

COURSE DESCRIPTOR

Course Code	**PST2MC03**
Course Title	**CATEGORICAL DATA ANALYSIS**
Credits	**04**
Hours/Week	**05**
Category	**MAJOR CORE(MC) - THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

- The subject of 'Categorical Data Analysis' is a major core area of Statistics with wide scope for application.
- The course aims at providing basic knowledge about inferential methods required to analyze categorical data that arise in several domains.
- The course introduces the interesting area of 'Generalized Linear Models' and imparts knowledge on different approaches needed for handling different types of response data.
- The methods taught in the course will enable students to handle predictive-modeling situations involving categorical data.
- The other topics related to categorical variables which the course seeks to expose to the students are symmetry and independence in data from matched pairs and modeling approaches for the same.

Course Objective:

- To introduce and give a feel for the interesting area of categorical data analysis to students.
- To give exposure on various summarizing and association measures for categorical variables.
- To equip students with the tools and techniques needed to analyse categorical data arising in various domains.
- To provide knowledge on concepts of inferential aspects with specific reference to categorical data.
- To expose high level ideas for building predictive models for categorical response **Variables.**

Prerequisites:	Distributions, Regression models

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Categorical response Data – Scales of measurement. Inferential procedures – Wald, Likelihood Ratio and Score Inference. 2 x 2 Contingency tables – Difference of proportions, Relative Risk, Odds Ratio. Tests of Independence – Pearson's Chi-square Test, LR Test, Residuals in contingency tables, Partitioned Chi-Square Analysis. Independence for ordinal variables.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Association Measures for three-way tables – Conditional and Marginal Association measures – Odds Ratios, Independence. Generalized Linear Models – Components. GLM for Binary and Count data – Binary Logit, Probit, Poisson and Negative Binomial Models. Inference for GLMs – Deviance and model comparison. Variable Selection using Forward, Backward and Stepwise.	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Logistic Regression – Interpreting Odds ratios. Logistic regression with retrospective studies. Diagnostics. Cochran-Mantel-Hanszel Test. Building Logistic Regression models – Stepwise algorithms, AIC & Model Selection, Goodness of fitt. Multicategory Logit models – Baseline Logits, Cumulative Logits, Adjacent-Categories Logits, Continuation-Ratio Logits. Generalized Cochran-Mantel-Hanszel Test.	15	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Loglinear models for two-way & three-way tables. Chi-squared goodness of fit test. Tests for conditional associations. Loglinear models for higher dimensions. Loglinear-Logistic connection. Strategies in model selection. Ordinal Association Models. Test for ordinal independence. Building of Probit models.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Models for matched pairs – Marginal models for Marginal Proportions, Conditional models for Matched Pairs. Comparing margins in square contingency tables – Marginal homogeneity for nominal & ordinal categories. Symmetry & Quasi-Symmetry – Testing marginal homogeneity, Quasi independence, Agreement modelling, Kappa Measure of agreement.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Book for Study:

1. Alan Agresti (2007). Categorical Data Analysis, 2nd Ed. Wiley: New York.

Books for Reference:

1. Collett, D. (2003). Modelling Binary Data, 2nd Ed. Chapman & Hall :London.
2. Cramer, J. S. (2003). Logit Models from Economics and Other Fields. Cambridge University Press : Cambridge.
3. Hosmer, D. W. and Lemeshow, S. (2000). Applied Logistic Regression, 2nd Ed. Wiley: New York.
4. Lloyd, C. J. (1999). Statistical Analysis of Categorical Data. Wiley, New york

Web Resources:

1. https://bit.ly/3v5qy9l
2. https://bit.ly/3v2eKVk
3. https://bit.ly/3p9j5Cf
4. https://bit.ly/3h7DAuA
5. https://bit.ly/3LRtkop
6. https://bit.ly/3H45VfT
7. https://bit.ly/3h8X2Hz
8. https://bit.ly/3I60f6u

COURSE OUTCOMES (COs)

PST2MC03 - CATEGORICAL DATA ANALYSIS (MC)		Cognitive Levels
CO 1	Explain the salient features of categorical data and summarize the same with suitable summary measures, , choose required inputs to relate with categorical outcomes and interpret the summary measures.	K1,K2
CO 2	Apply the methods of Statistical Inference to develop estimates of unknown characteristics of populations and carry out tests for hypotheses about the parameters.	K3
CO 3	Analyze a given situation involving categorical data for stakeholders, identify and build the suitable statistical model, interpret the estimates of the model parameters and recommend suitable actions to handle issues.	K4
CO 4	Construct predictive models to determine the nature of relationships of categorical response variables with inputs and predict categorical outcomes for a given set of inputs.	K5
CO 5	Examine and compare models, choose the appropriate one, modify it to improve its fit to the data and support stakeholders to scientifically decide on the ways to solve issues.	K6

COURSE DESCRIPTOR

Course Code	**PST2MC04**
Course Title	**RESEARCH METHODOLOGY**
Credits	**2**
Hours/Week	**3**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

- It encompasses the understanding and application of appropriate research design, statistics, and the use of the computer for data analyses, report writing and presentation.

Course Objective:

- Develop understanding on various kinds of research, objectives of doing research, research process, and research designs.
- Identify and discuss the concepts and procedures of sampling and data collection.
- Have adequate knowledge on measurement & scaling techniques.
- To impart knowledge for enabling students to develop data analytics skills and meaningful interpretation to the data sets so as to solve the business/Research problem.
- To familiarize various Statistical packages such as SPSS/R.

Prerequisites:	Basic Knowledge of Statistics

SYLLABUS

UNIT	CONTENT	HOURS	Cos	COGNITIVE LEVEL
I	Meaning of Research, Objectives of Research, Motivations in Research, Types of Research –Research Process-Research Design.	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Sampling, Methods of Data collection, Tools & techniques of Data collection - Determining size of the sample – Practical considerations in sampling and sample size.	**8**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Research proposal – Review of literature – Measurement – Scaling – Reliability and Validity.	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Re sampling Techniques: Bootstrap & Jacknife – EM Algorithm – Iterative methods of solving equations: Simulation – Monte carlo- MCMC methods.	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Use of tools / techniques for Research: methods to search required information effectively –Applications of statistical software's in Analysing Data & Solving Research Questions - Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.	**8**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Kothari C.R and Garig. (2014) Research Methodology: Methods & Techniques, New age international publishers.
2. Hogg R.V., McKean, J.W. Craig .A.T. (2013), Introduction to Mathematical Statistics

SUGGESTED READINGS

1. Venkatamuni Reddy,R. (2011). Fundamentals of Research (Concepts of Research Methodology, Statistics Econometrics and Mathematics
2. Efron,B. and Tibshirani. R.J. Chapman & Hall (1993). An introduction to the Bootstrap
3. Rubinstein, R.Y. (1981), Simulation and the Monte Carlo Method, John Wiley.
4. Panneerselvam.R, (2014). Research Methodology, PHI Pvt. Ltd, New Delhi.

WEB SOURCES

1. https://bit.ly/3vnN1ib
2. https://bit.ly/3BHgTHh
3. https://bit.ly/3BF00ga
4. https://bit.ly/3h1Obr8

COURSE OUTCOMES (COs)

PST2MC04 - Research Methodology (MC)		Cognitive Levels
CO 1	Discuss the various steps involved in conducting research and Recall the principles of research design, Research process and basic computer skills necessary for the conduct of research	K1, K2
CO 2	Identify the need for sampling and Explain the technique of developing measurement tools in research	K3
CO 3	Differentiate between various data collection methods in research, various scaling techniques used and Identify the various steps in sampling design	K4
CO 4	Explain the problems in processing of data in research studies and used in various phases of research	K5
CO 5	Develop skills in resampling Techniques and presentation skills	K6

URSE DESCRIPTOR

Course Code	**PST2MC05**
Course Title	**STATISTICS LAB – II (R AND PYTHON)**
Credits	**2**
Hours/Week	**4**
Category	**MAJOR CORE (MC) –LAB**
Semester	**II**
Regulation	**2022**

Course Overview:

- This course enlightens knowledge on Estimation, Testing and Model building.
- The estimation procedures and algorithm for estimation are discussed in R Platform.
- It focusses on power curves and testing of significance for small and large samples.
- Non-Parametric methods for univariate, bivariate and multivariate techniques are discussed.
- Model buildings for categorical data and it's validation are discussed in R Platform.
- The course emphasizes on the applications to real life problems using R Language.

Course Objectives:

- To explore practical knowledge of categorical data analysis using R Language.
- To apply non-parametric tests in real life using R Language.
- To get knowledge on decision making power with real time data using statistical software.
- To understand the business problems from CDA, Testing and Estimation and provide solutions using software.
- To provide solution from the estimation problems.

Prerequisites	Basic knowledge in computer, statistics and mathematics

SYLLABUS				
Unit	Content	Hrs	COs	Cognitive Level
I	UMVUE, MLE, method of moments, MLE through successive approximation, Interval Estimation, EM- algorithm, Bayesian Estimation, MCMC technique – Gibbs sampler, Jackknife and Bootstrap methods.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Most powerful test, Uniformly Most Powerful test, Likelihood Ratio test, Drawing Power curves, Tests of significance – small and large samples	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Chi-Square Goodness of fit test, Kolmogorov-Smirnov test, Test for randomness, Wilcoxon Signed rank test, Wald-Wolfowitz run test, Median test, Mann-Whitney U test, Kruskal-Walli's test and Friedman test.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Logistic Regression Models – Binary logistic model, Multi-category logistic model, Cumulative logistic model, Poisson model, Negative Binomial model. Model performance using AUC, test and train, leave one out validation.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Log-linear models for two-way & three-way tables, Agreement modelling, Kappa Measure of agreement.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Joaquim P. Marques de Sá, (2017), Applied Statistics Using SPSS, STATISTICA, MATLAB and R, Springer publication.
2. Johannes Ledolter, *(2013),* Data mining and Business analytics with R, John wiley

Suggested Readings

1. Michael J. Crawley, (2013) , The R Book, Wiley publication.
2. Eye A.V., and Mun, E.Y. (2012). Log-Linear Modeling : Concepts, Interpretation, and Application,

Web Resources

1. **https://bit.ly/3h5QCZJ**
2. **https://bit.ly/35gotwv**
3. **https://bit.ly/3H3wbHv**
4. **https://bit.ly/3IcLmzg**
5. **https://bit.ly/3JLZvUs**

Course Outcomes

COs	PST2MC05 – STATISTICS LAB II (R and Python)	Cognitive Level
CO1	To understand the basic concepts of Estimation, Testing and Model building.	K1, K2
CO2	To apply R programming skills for Estimation problem.	K3
CO3	To analyze and examine the testing of significance for small and large samples and non-parametric methods using R Language.	K4
CO4	To customize programming language for model building techniques.	K5
CO5	To generate conclusion for real time problem using R Programming.	K6

COURSE DESCRIPTOR

Course Code	**PST2ME01**
Course Title	**TIME SERIES MODELLING**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) –THEORY**
Semester	**II**
Regulation	**2022**

Course Overview

- This course enables students to gain understanding in various components of time series data and how to forecast time series for future time points.
- Additive and Multiplicative time series models, decomposition and forecasting with seasonality and trend components.
- Stationary and Non stationary time series and forecasting using AR and MA models
- Box Jenkins method of forecasting using ARIMA model
- Construction of ARCH and GARCH models for forecasting future volatility.

Course Objectives

- To understand the basic components of a time series data and how to decompose them into specific components for future forecast.
- To visualize time series data and autocorrelations within the data points
- To apply smoothing methods based on additive and multiplicative models for a given data and decide the best fit among the candidate models
- To determine the best ARIMA model parameters that best forecast the future
- To fit ARCH and GARCH model for forecasting future volatility

Prerequisites	Basic knowledge in Stochastic Process

SYLLABUS				
UNIT	**CONTENT**	**Hours**	**Cos**	**Cognitive Level**
I	Components of a Time Series, Additive Model - Multiplicative Model - Decomposition methods for additive and multiplicative model – Forecast based on additive and multiplicative models – Measures of Forecasting accuracy: MAE, MAPE, MSE - Autocorrelation function and ACF plot – Partial Autocorrelation and PACF plot- Durbin Watson Test.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Simple Exponential Smoothing – Holt's linear method - Additive damped trend method - Additive Holt-Winters' method - Multiplicative Holt-Winters' method - Holt-Winters' damped method – Forecasting using dummy variable linear regression with seasonality and trend components.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Stationary and Non-Stationary time series - Mean Stationarity – Variance Stationarity – Random walk – Random walk with drift- Differencing – Seasonal differencing – Back shift notation - Test for stationarity: The Dickey-Fuller Test for unit root	**11**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Auto regressive model of order one – Moving average model of order one – Auto regressive model of order p – Identifying AR order - Moving average model of order q – Identifying MA order. Box Jenkins method of forecasting using ARIMA – General ARIMA model form – Identification of ARIMA models –	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Forecasting using ARIMA model - Seasonal ARIMA model – Out of time model validation - Dynamic regression model form – Koyck model	**11**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Spyros, G. Makridakis, Steven C.Wheeleright and Rob J.Hyndman, (2014). Forecasting methods and applications Wiley publication, 3e.
2. Wilfredo Palma (2016), Time Series Analysis, Wiley Publication.

Suggested Readings

1. Ruey S. Tsay (2010). Analysis for Financial Time Series, , 3e, Wiley publication.
2. Rob J. Hyndman and George Athanasopoulos (2018), Forecasting Principles and Practice, OTexts publication, 2018.

Web Resources

1. **https://bit.ly/36yqp43**
2. **https://bit.ly/34RGKjW**
3. **https://bit.ly/3LR9ZUv**
4. **https://bit.ly/3LRfqCH**
5. **https://bit.ly/3BJJf3M**

Course Outcomes

PST2ME01 – TIME SERIES MODELLING (ME)		**Cognitive Level**
CO 1	To be able to visualize time series data, autocorrelations, partial autocorrelations and stationarity.	**K1, K2**
CO 2	To decompose the time series data into its specific components for future forecast	**K3**
CO 3	To apply smoothing methods and regression approach for forecasting	**K4**
CO 4	To fit AR, MA and ARIMA model and determine the best candidate model	**K5**
CO 5	To fit ARCH and GARCH model for forecasting future volatility	**K6**

COURSE DESCRIPTOR

Course Code	**PST2ME02**
Course Title	**RELIABILITY THEORY**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) - THEORY**
Semester	**II**
Regulation	**2022**

Course Overview

- Reliability theory summarizes the basic concepts of risk, reliability and safety and the methodologies to define reliability in a quantitative manner to aid to design for reliability.
- To introduce students to modern computational and theoretical techniques to assess the reliability of systems as a function of their component probabilities of failure, and to illustrate how importance measures are useful in engineering decision making.
- The course will explore advanced topics on system reliability and their time evolution, and will provide insights into emerging numerical and analytical modeling techniques, computational complexity, load combinations, and the role of normative design standards.
- The course emphasizes Reliability components and their applications in real life through s case studies.

Course Objective

- This course covers the main statistical methods used in reliability and life data analysis.
- The main distributions used in reliability data analysis are overviewed.
- The ageing properties of different distributions are explored.
- A course in reliability helps in probabilistic modelling of the reliability of systems with multiple components and statistical modelling of reliability of individual components based on lifetime data.

Prerequisites	Basic Calculus, elementary probability theory and statistics and elementary stochastic processes

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Reliability concepts and measures; components and systems; Series, Parallel, hybrid system, coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; - parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals; closures or these classes under formation of coherent systems, convolutions and mixtures.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Univariate shock models and life distributions arising out of them; cumulative damage model, shock models leading to univariate IFR, Successive shock model; bivariate shock models; common bivariate exponential distributions and their properties.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. Maintenance and replacement policies; availability of repairable systems, modeling of a repairable system by a non-homogeneous Poisson process.	**11**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Barlow R.E. and Proschan F.(1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless J.F. (2002): Statistical Models and Methods of Life Time Data. 2nd Edition. John Wiley.

SUGGESTED READINGS

1. Bain L.J. and Engelhardt. (1991): Statistical Analysis of Reliability and Life Testing Models. 2nd Edition. CRC Press.
2. Nelson, W. (2003): Applied Life Data Analysis; Wiley Inter science.
3. Zacks, S. (1992): Introduction to Reliability Analysis, Springer Verlag.

WEB SOURCES

1. https://www.weibull.com
2. https://www.ntnu.edu
3. http://www.nitjsr.ac.in
4. https://cutt.ly/3O8jigA
5. https://cutt.ly/nO8jYO2
6. https://cutt.ly/kO8jNmQ
7. https://cutt.ly/mO8kpAn

COURSE OUTCOMES (COs)

PST2ME02 - RELIABILITY THEORY (ME)		Cognitive Levels
CO 1	To **recognize** and **explain** reliability models for simple technical systems in terms of concepts like component wise and system wise redundancy, and series and parallel structures	**K1, K2**
CO 2	To **apply** theories and methods to find overall solutions on safety, reliability and maintainability challenges for industrial applications and public administration	**K3**
CO 3	To **Analyses** and judge models, methods, analysis tools, calculations and information techniques, and choose among alternative solutions and concepts	**K4**
CO 4	To **modify** and **integrate** complex disciplinary questions and challenge to establish knowledge and practise within the Reliability idea.	**K5**
CO 5	To **investigate**, **develop**, **operate** and **maintain** safe, reliable and maintenance friendly systems.	**K6**

COURSE DESCRIPTOR

Course Code	**PST2ME03**
Course Title	**PROBABILITY THEORY**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) – THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

- Probability theory is the branch of mathematics that deals with modeling uncertainty and has direct application in many areas and also forms the fundamental basis for many other areas, including statistics, optimization methods and risk modeling**.**
- This course covers many areas of probability theory including axiomatic foundations, random variables, distributions and densities; transformations and expectations; introduces both discrete and continuous families of distributions; multiple random variables: convergence.
- In this course, axioms of Probability theory are understood to have working knowledge with probability calculations behind hierarchical model building.
- The students are made aware of different types of convergence
- The goal of this course is to teach basics of probability along with the application

Course Objective:

- To introduce the fundamentals of probability theory and random processes.
- To apply the statistical and mathematical formulations for handling a range of business-based problems.
- To present the basic principles of random variables and random processes needed in applications
- Develop problem-solving techniques needed to accurately calculate probabilities.
- Apply problem-solving techniques to solving real-world events.

Prerequisites:	Basic Knowledge of Mathematics and Statistics.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Spaces, Classes of sets, Probability measures, Lebesgue measure on unit interval. Extension of measures – Uniqueness. Monotone class, Completeness. Limit sets	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Independent events – Borel-Cantelli Lemmas, Zero-One Law. Simple random variables – Independence, Expected values, Inequalities. Strong and Weak Laws (Without Proof).	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Measures – Counting Measure, Lebesgue Measure – Measures in Euclidean Spaces. Measurable mappings. Distribution Function. Measure Integrals – Lebsgue and Lebesgue-Stieltjes Integrals. Product Measures – Fubini's Theorem. Radon-Nikodym Theorem.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Random variables and vectors – Sequences of rv's – Convolution. Convergence in Probability. Expected Values – Moments, Inequalities. Independence – Moment Generating Functions. Strong and Weak Laws (With Proof).	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Convergence in Distribution– Fundamental Theorems. Characteristic functions – Moments and Derivatives – Inversion and Uniqueness Theorem. Central Limit Theorem – Identically distributed summands. Lindberg and Lyapounov Theorems.	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books:

1. Billingsley, P. (1991). Probability and Measure, 2nd Edition. John Wiley & Sons, Singapore.

Suggested Reading:

1. Athreya, K. B. and Lahiri, S. (2006) Probability Theory. Hindustan Book Agency.
2. Bhat, B.R. (2007). Modern Probability Theory, 3rd Ed. New Age International Publishers.
3. Rohatgi, V.K. and Saleh, A.K.Md.E (2002). Introduction to Probability and Statistics, Pearson Education, Asia

WEB SOURCES

1. https://www.coursera.org/courses?query=probability%20theory
2. **https://www.edx.org/learn/probability**
3. **https://www.mooc-list.com/tags/probability-theory**
4. **https://nptel.ac.in/courses/111/104/111104079/**

COURSE OUTCOMES (COs)

PST2ME03 – PROBABILITY THEORY (ME)		Cognitive Levels
CO 1	To understand sets and basics of measure theory.	K1, K2
CO 2	To apply the concept of simple and independent random variables in probability theory.	K3
CO 3	To apply the concepts of measure theory in understanding probability theory.	K4
CO 4	To evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits	K5
CO 5	To analyse various modes of convergence of random variables and to apply central limit theorems.	K6

Course Descriptor

Course Code	**PST2CD01**
Course Title	**STATISTICAL ANALYSIS**
Credits	**01**
Hours/Week	**03**
Category	**CROSS DISCIPLINARY (CD) -THEORY**
Semester	**II**
Regulation	**2022**

Course Overview:

1. Discuss the application of statistical techniques that helps to summarize the data.
2. Introduces basic distributions and sampling distributions.
3. Able to make statistical comparison of means and variances.
4. The students are made aware of analysis of variance (ANOVA) and linear regression.
5. The goal of this course is to teach basic applications of Statistics.

Course Objective:

1. To develop theoretical knowledge in Statistical analysis.
2. To learn the application of Statistical techniques.
3. To analyse the data and interpret the results.
4. To be able to apply the techniques in different areas

Prerequisites:

Basic Knowledge of Mathematics and Statistics.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**CO's**	**COGNITIVE LEVEL**
I	Basic probability – addition, Multiplication – Baye's theorem – Simple problems	7	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5
II	Basic distributions- Binomial, Poisson, Normal. Applications, Normal distribution as a limiting case of Binomial and Poisson.	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5
III	Test of significance- large sample and small sample tests, test for population mean, variance (one sample and two sample), F- test.	9	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5
IV	Chi-square test for goodness of fit, contingency tables and taking independence of attributes, ANOVA- one way and two way classifications.	9	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5
V	Correlation and Linear regression- regression model, linear regression equations, regression coefficients.	6	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5

Text Books:

1. S.P., Gupata and M.P., Gupta (2013). Business Statistics, Sultan Chand & Sons, New Delhi.
2. Gupta S. C. and Kapoor V. K., (2020), Fundamentals of Mathematical Statistic, Sultan Chand & Sons, New Delhi.
3. Tamhane A.C. and Dunlop D.D. (2000), Statistics and data analysis: from elementary to intermediate, Prentice Hall, Upper Saddle River, NJ.

Suggested Reading:

4. Hogg R.V., Craig, A. And McKean J. W. (2012) , Introduction to Mathematical Statistics, 7 Ed, Pearson Publishers.
1. Montgomery, D.C., Peck, E.A. and Vining, G.G. (2003), Introduction to Linear regression analysis, John Wiley & Sons. Inc.NY.
2. Rohatgi, V.K. and Saleh. A.K. Md.E., (2003), An introduction to probability theory and Mathematical Statistics, John Wiley & Sons.

Web Sources:

1. http://campus.murraystate.edu/academic/faculty/cmecklin/STA135/_book/probability-rules-and-bayes-theorem.html
2. https://www3.nd.edu/~rwilliam/stats1/x11.pdf
3. http://www.stat.yale.edu/Courses/1997-98/101/sigtest.htm
4. https://www.simplypsychology.org/anova.html
5. https://www2.sjsu.edu/faculty/gerstman/StatPrimer/cont-cont.htm

Course Outcome

	CO Description	**Cognitive Level**
CO 1	To understand the basic concepts in distribution.	K1, K2
CO 2	Expertise in the field of Statistical theory.	K3
CO 3	To differentiate between large and small sample test.	K4
CO 4	To understand the important applications	K5
CO 5	To develop a deeper understanding in analysis.	K6

III Semester

COURSE DESCRIPTOR

Course Code	PST3MC01
Course Title	MULTIVARIATE ANALYSIS
Credits	06
Hours/Week	06
Category	MAJOR CORE (MC) – THEORY
Semester	III
Regulation	2022

Course Overview:

- Multivariate analysis is part of exploratory data analysis. Based on MVA, we can visualize the deeper insight of multiple variables.
- **Multivariate analysis (MVA)** is a Statistical procedure for analysis of data involving more than one type of measurement or observation. It may also mean solving problems where more than one dependent variable is analyzed simultaneously with other variables.
- Multivariate analysis considers more than one factor of independent variables that influence the variability of dependent variables; the conclusion drawn is more accurate.
- This course helps the students to use multivariate techniques appropriately, undertake multivariate hypothesis tests, and draw appropriate conclusions.
- This course help the students to understand the fundamental theory behind multivariate distributions and, through data examples, learn to fit, examine, and utilize multivariate analysis technique to examine relationships between multiple variables and also to reduce the dimension.

Course Objective:

- To develop a deeper understanding of the multivariate analysis and its limitations;
- To understand how to diagnose and apply corrections to some problems with the generalized linear model found in real data
- To be able to carry out multivariate statistical techniques and methods efficiently and effectively.

Prerequisites:	Basic Knowledge of Mathematics (Matrix Algebra), Distribution theory.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Multivariate Normal distribution – Properties, Distributions of linear combinations, independence, marginal distributions, conditional distributions, Partial and Multiple correlation coefficient in multivariate setup.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Distributions of Sample correlation coefficient, Partial correlation coefficient & Multiple correlation coefficient. Maximum Likelihood Estimation of MV normal parameters – Likelihood ratio testsfor mean vectors -The Generalized T^2 Statistic and its distribution and applications. Hotelling's T^2 (one and two samples), Mahalanobi's D^2 statistic, Fisher-Behren problem.	**16**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Generalized variance – Wishart distribution (statement only) – Properties of Wishart distribution –Paired comparisons & Repeated Measures design, MANOVA (one way and two-way) Profile analysis- Test for covariance matrix – Test for equality of covariance matrices Sphericity test	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Principal Components. Factor Analysis – Orthogonal Factor model, Factor rotation, Factor scores. Canonical Correlation Analysis.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Discrimination & Classification –Bayes' procedures, Fishers approach, more than two groups, selection of variables. Optimality of classification rules. Discrimination & classification for several populations. Cluster Analysis –proximity data. Similarity measures, Hierarchical & Non-Hierarchical methods.	**16**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Anderson, T. W. (2003). An Introduction to Multivariate Statistical Analysis 3rd Ed . John Wiley & Sons.
2. Johnson, R. A., & Wichern, D. W. (2007). Applied Multivariate Statistical Analysis 6th Ed. Prentice Hall International
3. Giri, N.C. (2003). Multivariate Statistical Inference, Academic Press, NY

SUGGESTED READINGS

1. Everitt, B.S. & Dunn, G. (2001). Applied multivariate Data analysis, 2nd edition, Arnold publishers, London.
2. Morrison, D.F. (1990). A multivariate statistical methods, 3rd edition, Mc Graw hall, New Delhi.

WEB SOURCES

1. https://www.kaggle.com/
2. https://nptel.ac.in/courses/111/104/111104024/
3. https://cutt.ly/vPDyBvM
4. https://cutt.ly/BPDyMuu

COURSE OUTCOMES (COs)

PST3MC01 - MULTIVARIATE ANALYSIS (MC)		Cognitive Levels
CO 1	To develop methods of handling data analysis of several variables simultaneously and Necessary theoretical results on multivariate distributions and understanding of different multivariate techniques.	**K1, K2**
CO 2	To analyze the real life data using multivariate tools like- factor analysis, discriminant analysis, cluster analysis, principal component analysis.	**K3**
CO 3	To Evaluate necessary theoretical and mathematical understanding of the multivariate processes and to defend multivariate data analysis on real life data using statistical packages and interpret the results.	**K4**
CO 4	To classify and assign a new item/object to any of the two or more populations using Discrimination and Classification and to group variables or items that belong to multi-dimensional data using Cluster algorithms.	**K5**
CO 5	To describe and develop scientific view to deal with multidimensional datasets and uses in the analysis of research data.	**K6**

COURSE DESCRIPTOR

Course Code	**PST3MC02**
Course Title	**ADVANCED STOCHASTIC PROCESSES**
Credits	**06**
Hours/Week	**06**
Category	**MAJOR CORE (MC) - THEORY**
Semester	**III**
Regulation	**2022**

Course Overview:

- Advanced Stochastic Processes deals with mathematical models of systems and phenomena that appear to vary in a random manner.
- This course provides the classification and types of stochastic processes.
- The aim of the course is to emphasize on Markov process and its applications.
- The study of Discrete time Markov chains involving Transition probability matrix, Limiting probabilities and Stationary distribution is made.
- Continuous time Markov chains comprising of Poisson process, Birth process , Birth and Death process, Renewal process , Branching process and Brownian motion process and their properties are studied

Course Objective:

- To understand the concept of Stochastic process and its types.
- To comprehend the transition probabilities of one-step and n-step and Chapman - Kolmogorov equation.
- To know how to calculate limiting probabilities and find stationary distribution.
- To derive the distribution of Poisson process, Birth process, Birth-Death process, Renewal , Branching process and Brownian motion process.
- To apply the various Stochastic processes in real life situations.

Prerequisites:	Mathematical Knowledge

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Elements of stochastic processes-Simple examples-Classification of general stochastic processes-Process with stationary independent increments-Properties-Markov chains-Spatially homogeneous Markov chains .One-dimensional random walks. A discrete queueing Markov chain - Inventory model - Success runs. Classification of states of a Markov chain - Periodicity of a Markov chain - Recurrence-Criteria for recurrence - Examples. Basic limit theorem of Markov chains (Statement only) - Stationary probability distribution - Absorption probabilities.	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Continuous time Markov chains - General pure birth process-Poisson process - Pure death process - Yule process - Birth and Death process - Examples-Differential equations for Birth and Death process - Finite state continuous time Markov chains.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Renewal process - Definition and related concepts – Examples - Poisson process viewed as Renewal process - Replacement models - Counter models - Elementary renewal theorem. Martingales - Definition - Examples - Supermatingales and Submartingales - Elementary properties. Fundamental Theorems	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Branching process- Definition- Discrete time Branching process-Generating function relations - Extinction probabilities - Examples. Two contrasting stationary processes-Trigonometric polynomials - Moving average processes - A stationary process on the circle-Stationary Markov chains.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Brownian motion process - Joint probabilities for Brownian motion-Continuity of paths and Maximum variables - Variations and Extensions - Brownian motion reflected at the origin-Brownian motion absorbed at the origin-Brownian motion with drift - Geometric Brownian motion - Comparing some functional of Brownian motion by Martingale methods.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Karlin, S. and Taylor, H. M. (1978) . A First Course in Stochastic processes ,Academic Press, New York.
2. Medhi, J. (1996) . Stochastic Processes , Wiley Eastern Ltd. New Delhi.

SUGGESTED READINGS

1. Taylor, H. M. and Samuel Karlin (1998). An Introduction to Stochastic modelling, Academic Press, New York.
2. Ross, S. M. (1983). Stochastic Processes, John Wiley and Sons, New York.
3. Durrett, R (2016) Essentials of Stochastic Processes, Third Edition , Springer International Publishing, Switzerland.
4. Hoel, P.G. Port S.C.and Stone, C. J. (1987). Introduction to Stochastic Processes, Waveland Press Inc., U.S.A.
5. Karlin, S and Taylor H. M. (1981). A Second Course in Stochastic Processes, Academic Press, New York.

WEB SOURCES

1. https://searchworks.stanford.edu
2. https://www.journals.elsevier.com
3. https://www.routledge.com
4. https://www.researchgate.net
5. https://www.coursera.org

COURSE OUTCOMES (COs)

PST3MC02 - ADVANCED STOCHASTIC PROCESSES (MC)		Cognitive Levels
CO 1	To define the different types of stochastic processes and provide examples for them.	K1, K2
CO 2	To classify the Stochastic process and compute one-step and n-step transition probabilities, excess and current life for renewal process and extinction probabilities for branching process.	K3
CO 3	To apply Chapman-Kolmogorov equation for deriving various processes and examine the recurrence for the states of Markov chain.	**K4**
CO 4	To compare Poisson process, birth and death process, renewal process, branching process and Brownian motion process and analyse their properties.	**K5**
CO 5	To organize various processes with respect to their applications.	**K6**

Course Descriptor

Course Code	**PST3MC03**
Course Title	**DATA MINING AND MACHINE LEARNING**
Credits	**4**
Hours/Week	**4**
Category	**MAJOR CORE (MC) – THEORY**
Semester	**III**
Regulation	**2022**

Course Overview

- This course provides an introduction of data process and data mining tools
- Data mining tools limitations and applications are explained
- This course focuses on data analysis skill development in finding appropriate data mining tools for the available dataset.
- Supervised and unsupervised data mining tools are discussed
- The course emphasizes on the applications to real life problems.

Course Objectives

- To understand data mining architecture and data processing for data analysis.
- To apply the various techniques of decision tree tools
- To understand classification and regression problems and it's real time applications.
- To know the methodology for validation of regression and classification problems.
- To apply various classifier algorithms and text mining methods.

Prerequisites	Basic knowledge in statistics and mathematics

SYLLABUS				
Unit	**Content**	**Hrs**	**COs**	**Cognitive Level**
I	Basic concepts of data mining – Definition, Applications, CRISP- DM architecture, Different types of data, Issues of data mining. Data understanding, processing, cleansing and data preparation.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Understanding of supervised and non-supervised modelling. Decision Tree Methods - Classification Tree, Regression Tree and Random Forest. Decision tree based on Statistical Significance - Chi Square Automated Interaction Detector (CHAID).	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Naive Bayes Classification Method, Bayesian Networks, Back Propagation Algorithm, Building Predictive Model using Artificial Neural Network, Support Vector Machine, Comparing Classifier Accuracy.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Construction of Gains Chart, ROC Curve, Leave one out validation and N fold validation, Construction of Logit Model Tree, K^{th} Nearest Neighbourhood Classification, Bagging and Boosting Principles, Adaptive Boosting Algorithm, Apriori Algorithm and Association Rule Mining	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Understanding of Additive Regression, Logit Boost, Multi Class Classifier, Ordinal Class Classifier, Expectation Maximization Algorithm, Genetic Algorithm, Combining Classifiers, Cost Sensitive Classifier, Text Mining– Methods and Models	**11**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Larose, D.T. and Larose, C.D, (2014). Discovering knowledge in data: An introduction to data mining, 2nd Edition, Wiley publication
2. Larose, D.T. and Larose, C.D. (2015). Data Mining and Predictive Analytics 2nd Edition, Wiley Publication.
3. Hastie, T. Tibshirani, R. and Friedman, J. (2017). Elements of Statistical Learning: Data Mining, Inference and Prediction, 2nd Edition, Springer.

Suggested Readings

1. Russell, M. A., Klassen, M, (2019} Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Instagram, GitHub, and More,3rd Edition, O'Reilly Media.
2. Provost, F. and Fawcett, T. (2013). Data science for Business: What you need to know about data mining and data analytics Thinking, 1st Edition. O'Reilly Media.

Web Resources

1. https://cutt.ly/cPDoN8t
2. https://cutt.ly/RPDo2AD
3. https://cutt.ly/gPDoCih
4. https://cutt.ly/kPDo8jY
5. https://cutt.ly/zPDo7SN
6. https://cutt.ly/GPDpqtj
7. https://cutt.ly/1PDpryp

Course Outcomes

Cos	PST3MC03 - DATA MINING AND MACHINE LEARNING (MC)	Cognitive Level
CO1	To understand the data preparation and basic data mining concepts.	**K1, K2**
CO2	To compute data mining tools for classification problems.	**K3**
CO3	To apply data mining tools for regression problems.	**K4**
CO4	To analyze the real life data using data mining tools such as supervised and unsupervised tools.	**K5**
CO5	To generate optimize report for the given data using appropriate data mining **tools.**	**K6**

COURSE DESCRIPTOR

Course Code	**PST3MC04**
Course Title	**STATISTICS LAB – III (PYTHON)**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR CORE (MC) - LAB**
Semester	**III**
Regulation	**2022**

Course Overview:

- To Provide Practical Knowledge in analyzing problems in Multivariate Analysis.
- To learn Advanced Stochastic Processes and Data mining techniques.
- To demonstrate hands on experience for problems using statistical software
- To expose students to interpret the output and provide recommendations.
- To demonstrate knowledge of statistical data analysis techniques utilized in business decision making.

Course Objective:

- To learn data collection strategies and obtain data from a number of open data sources
- To develop skills of Data analysis using Multivariate analysis techniques and stochastic Processes
- To Choose the right algorithms for data mining problems
- To Develop and apply critical thinking, problem-solving, and decision-making skills.

Prerequisites:	Advanced knowledge in Multivariate Analysis, Stochastic Processes and Data mining Concepts.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Computation of Means, Variances, Covariance and Correlations from a Multivariate dataset. Computation of Partial correlation coefficients from the Var -Cov matrix of a multivariate normal population. Computation of Multiple Correlation coefficients from the Var - Cov matrix of a multivariate normal population.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Tests for significance of correlation coefficient using samples from multivariate normal populations– Simple Correlation, Partial correlation and Multiple correlation coefficients. Applications of T^2 Statistic to different situations – Test for mean of a single MV normal population, Test for equality of mean vectors of two MV normal populations with equal Var - Cov matrices & unequal Var- Cov matrices, Special Applications. MANOVA – One-way & Two-way models. Principal component analysis.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Factor Analysis - Canonical Correlation Analysis - Fishers Discriminant Analysis – Two populations, several populations. Classification with Prior Probabilities. Cluster Analysis – Hierarchical method with different linkages, K-Means method	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Determination of n^{th} order transition probability matrix - Determination of stationary distribution - Generating a Poisson process; waiting time distribution - Extinction probability in a branching process.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Segmentation using CART and CHAID Classification and prediction using Random Forest - Predictive model building using ANN, SVM and KNN - Market Basket Analysis Prediction using Adaboost and Bayesian Network.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Dennis, D.J. (2021), Applied Univariate, Bivariate, and Multivariate Statistics Using Python: A Beginner's Guide to Advanced Data Analysis, Wiley.
2. Kane, F. (2017). Hands-On Data Science and Python Machine Learning, Packt Publishing Limited.

Suggested Readings

1. Bruce, P., Bruce, A. and Gedeck, P. (2020). Practical Statistics for Data Scientists, O'Reilly Media, Inc.
2. Motwani, B. (2020). Data Analytics using Python, Wiley.

Web Resources

1. https://readthedocs.org/projects/python-for-multivariate-analysis/downloads/pdf/latest/
2. https://newoutlook.it/download/python/learning-data-mining-with-python.pdf
3. https://www.cin.ufpe.br/~embat/Python%20for%20Data%20Analysis.pdf
4. https://python-course.eu/machine-learning/random-forests-in-python.php

COURSE OUTCOMES (COs)

PST3MC04 - STATISTICS LAB - III MC(L)		Cognitive Levels
CO 1	To **understand** the Python software and learn how to work with data type, data visualization and associated packages & libraries.	**K1, K2**
CO 2	**To integrate and access** the data base from different source of file format.	**K3**
CO 3	**To analyse** and apply Multivariate analysis and stochastic process technique working with data sets.	**K4**
CO 4	**To recommend** the suitable machine learning technique for statistical analysis.	**K5**
CO 5	**To Apply** statistical modelling and interpret inferential procedures for analyse the real life data.	**K6**

COURSE DESCRIPTOR

Course Code	**PST3ME01**
Course Title	**ADVANCED OPERATIONS RESEARCH**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) - THEORY**
Semester	**III**
Regulation	**2022**

Course Overview:

- Operations research (OR) has many applications in science, engineering, economics, and industry and this course provides the opportunity to solve OR problems which is crucial for both researchers and practitioners.
- Being able to solve the real-life problems and obtaining the right solution requires understanding and modeling the problem correctly and applying appropriate optimization tools and skills to solve the mathematical model.
- The goal of this course is to teach you to formulate, analyze, and solve mathematical models that represent real-world problems.
- In particular, we will cover linear programming, integer programs, nonlinear programs, dynamic programming, inventory control, queueing models and simulation.

Course Objective:

- To introduce students to use quantitative methods and techniques for effective decisions–making
- To introduce the applications of mathematical methods in solving day to day problems.
- To analyse multi-level decision problems and solve using suitable method
- To formulate models and applications that are used in solving business decision problems.
- Identify and develop operational research models from the verbal description of the real system.

Prerequisites:	Basic Knowledge of Mathematics and Statistics.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	General Linear programming problem-Formulation-Solution through Graphical, Simplex, Big-M and Two phase Methods – Duality in Linear programming.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Integer Programming-Branch and Bound and Cutting plane methods- Dynamic Programming - Solution of LPP by DPP	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Non-linear programming-Kuhn Tucker method-Lagrangian multipliers method. Quadratic programming problems -Wolfe's and Beale's algorithm.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Inventory control: Deterministic Models – Economic Order Quantity – Problems with no shortages – The fundamental EOQ Problems, EOQ problems with several production runs of unequal length - Queuing theory-(M/M/1): (GD/∞/∞), (M/M/1): (GD/N/∞), (M/M/C): (GD/∞/∞), (M/M/C): (GD/N/∞).	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Simulation- Formulating and Implementing a Simulation model, its applications, Monte Carlo method, generation of random numbers from probability distributions, variance reduction techniques, regenerative method.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Hiller, S.F. and Lieberman J.G. (2000). Operations Research, CBS Publishers & Distributors, New Delhi.
2. Hadley, G. (1997). Non-Linear Programming and Dynamic Programming, Addison-Wesley, New York.
3. Kambo, N. S. (1982). Mathematical Programming Techniques, East-West press.
4. S.D. Sharma., Operations Research - Theory, Methods & Applications, (1992) Kedar Nath Ram Nath & Company,

SUGGESTED READINGS

1. Philips, D.T. and Ravindra, A.& Solberg, J. (1976). Operation Research, Principles &Practice, John Wiley, New York.
2. Taha, H.A. (1999) . Operations Research-An Introduction, Macmillan Publishing, Company, New York.
3. Wagner, M. W. (1973). Principles of Operations Research: with applications to managerial decisions, Prentice Hall of India, New Delhi.

WEB SOURCES

1. https://nptel.ac.in/courses/110/106/110106062/
2. https://cutt.ly/KPDsvzh
3. https://www.mooc-list.com/tags/nonlinear-programming

COURSE OUTCOMES (COs)

PST3ME01 - Advanced Operations Research (ME)		Cognitive Levels
CO 1	To introduce the applications of mathematical methods in solving day to day problems.	K1, K2
CO 2	To understand the difference between various linear and non-linear programming models.	K3
CO 3	To analyse multi-level decision problems and solve using suitable method	K4
CO 4	To evaluate the best possible programming method to be used based on assessing the model.	K5
CO 5	To construct specialized linear programming problems, demonstrate solution process.	K6

COURSE DESCRIPTOR

Course Code	**PST3ME02**
Course Title	**ACTUARIAL STATISTICS**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) – THEORY**
Semester	**III**
Regulation	**2022**

Course Overview:

- Students learn about insurance risk calculation, insurance premiums, application of economic and mathematical analyses for making any decision in financial planning, insurance investment.
- Students learn about the discipline that assesses finance and applies the mathematics of probability and statistics to define, analyse, and solve the financial implications of uncertain future events.
- This course deals with evaluating risks and maintaining the economic stability of insurance or financial organizations.
- To motivate students to become Actuaries, who work for life, health, and property/casualty insurance companies, as well as for consulting firms, government agencies, accounting firms, industrial corporations, banks, and financial services companies.
- They use mathematics, statistics, and financial theory, actuaries define the financial impact of uncertain events—from catastrophes to rates of mortality, disability, and fertility—allowing businesses to adjust their long-term management strategies accordingly.

Course Objective:

- To introduce the applications of mathematics and statistics in insurance industry.
- To recognize the important role of statistical principles and their application.
- To use analytical skills in actuarial statistics.
- To access the financial impact of uncertain events.
- To motivate students to become Actuaries.

Prerequisites:	Basic Knowledge in Mathematics and Statistics.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**CO's**	**COGNITIVE LEVEL**
I	Compound Interest, force of interest-Accumulated value and present value annuities certain, present values, amounts, annuities, perpetuities, Redemption of loans. Continuous annuity, PV and AV.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Additional features of compound interest and Annuities certain, Nominal and effective rates of discount – capital redemption of policies	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Future life time distribution and density function, concept of force of mortaliy, future lifetime random variable, its pmf, deferred probabilities, its Mortality tables – construction of mortality tables comparison of different mortality tables, analytical loss of mortlity such as Gompertz law and Makehams law, single decrement life table, select and ultimate life table.	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Life Assurance premiums – Assurance benefits – Life annuities and temporary annuities, means and variances of present value of random variables of the payments under the assumption of constant force of payments, when benefit payments are made at the end of death– Net premiums for assurance plans – Net premiums for Annuity plans-premium conversion table.	12	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Office premiums – policy values – Other life contingencies - methods of valuation – Data for valuation – special reserves and adjustments.	10	CO1 CO2 CO3 CO4	K1 K2 K3 K4
			CO5	K5 K6

Text Book:

1. Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C. J. (1997). Actuarial Mathematics, *Ed by* Bowers, N. L., Society of Actuaries, Itasca, USA 2nd edition.
2. Dixit, S.P. , Modi, C.S, and Joshi, R.V. (2000) Mathematical basics of Life Assurance, Insurance Institute of India, Bombay.
3. Donald, D.W.A. (2016). Compound Interest and annuities. Cambridge University Press

Suggested Reading:

1. Mccutcheon, J.J. and Scot W. F. (1989). Introduction to Mathematics of Finance, Heinemann, London
2. Neil, A. (1977). Life contingencies, Butterworth-Heinemann, London
3. Spurgeon, E.F. (1972). Life Contingencies, Cambridge University Press.

WEB SOURCES

1. https://www.edx.org/learn/actuarial-science
2. https://nptel.ac.in/courses/112/107/112107260/
3. https://www.edx.org/course/introduction-to-actuarial-science

COURSE OUTCOMES (COs)

PST3ME02 - Actuarial Statistics (ME)		Cognitive Levels
CO 1	To introduce the applications of statistics in insurance industry.	K1, K2
CO 2	To recognise the important role of statistical principles and their application in actuarial science	K3
CO 3	To interpret and analyse actuarial and statistical information using analytical skills.	K4
CO 4	To apply mathematical, statistical, and financial theory to access the financial impact of uncertain events.	K5
CO 5	To motivate students to become Actuaries, who work for life, health, and property/casualty insurance companies, as well as for consulting firms, government agencies, accounting firms, industrial corporations, banks, and financial services companies.	K6

COURSE DESCRIPTOR

Course Code	**PST3ME03**
Course Title	**SPATIAL STATISTICS**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR ELECTIVE (ME) – THEORY**
Semester	**III**
Regulation	**2022**

Course Overview:

- This course is intended to give introduction to spatial statistics.
- It provides the background necessary to investigate geographically represented data.
- It will help the students to collect spatial data using sampling plans.
- It will cover the main areas of data quality, parameter estimation and testing of hypothesis.
- It gives an overview of the methods needed to analyze data for which it is suspected that the spatial component plays an important role.

Course Objective:

- Understand the concepts of spatial statistics.
- Obtaining spatial data through sampling.
- Apply the concepts relating to data quality.
- To analyse the data using inference procedures.
- Use the software R to perform spatial analysis of real data sets.

Prerequisites:	Basic background knowledge in statistics at the level of regression as well as in statistical computing. It is also required to have knowledge in GIS.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Generic issue of place, context and space – GIS – Location as place and context – Location and spatial relationship. Nature of Spatial data: Spatial data matrix – Geographical space: Objects, fields and geometric representations – Spatial dependence in attribute values – Classifying variables – Levels of measurement – Model quality – Data quality.	**12**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Sources of spatial data – Spatial sampling – Design and model based approaches to Spatial sampling – Sampling plans – Design based estimation of the population mean – Model based estimation of means – Spatial prediction.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Errors in data – Models for measurement error – Independent error models – Spatially correlated error models – Testing for outliers in large data sets – Error propagation – Data resolution – Variable precision and tests of significance – Areal interpolation.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Inference – Parameter estimation – Identifying valid hypothesis – Data consistency – Data completeness – Missing data problem – Spatial interpolation – Spatial prediction.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Descriptive statistics – Univariate plots: Histograms, Box plots. Bivariate plots: Simple scatter plots, symbols plot – Spatial Correlation analysis – Spatial Regression analysis.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Anselin, L. (2003). GeoDa 0.9 User's Guide, Center for Spatially Integrated Social Science.
2. Lensley, G. and Cheshire, J, (2016). An introduction to Spatial Data Analysis and Visualization in R.
3. Haining, R. (2003). Spatial Data Analysis – Theory and Practice, Cambridge University press.
4. Bivand, R. S. and Pebesma, E. J. (2008). Applied Spatial Data Analysis with R, Springer.

Suggested Readings

1. Bailey, T.C and Gatrell. A.C, (1995). Interactive Spatial Data Analysis, Essex, England, Prentice Hall 1st edition.
2. Cressie. N, (2015). Statistics for spatial data, Wiley Interscience, 2nd edition.
3. Epi Info, Mapping Open source Software Manual, (2003).
4. Gelfand A.E, P.J. Diggle, M. Fuentes and P. Guttorp, (2011). Handbook of Spatial Statistics, CRC Press.
5. Diggle, P.J. and Ribeiro, R.J. (2007). Model based Geostatistics, Springer 2nd edition.
6. Bailey,T.C. and Gatrell,A.C. (2009). Interactive Spatial Data Analysis, Prentice Hall, 2nd Edition.

Web Resources

1. https://cutt.ly/8PDEsU8
2. https://cutt.ly/SPDEhgk
3. https://cutt.ly/mPDEzik
4. https://cutt.ly/yPDEb9K

COURSE OUTCOMES (COs)

PST3ME03 - SPATIAL STATISTICS (ME)		Cognitive Levels
CO 1	To understand the concepts of spatial data, data collection and data analysis.	**K1, K2**
CO 2	To apply sampling plans, inference procedures, correlation and regression analysis using R for spatial data.	**K3**
CO 3	To analyse spatial relationships, data consistency and data completeness.	**K4**
CO 4	To explain spatial dependence in attribute values, spatial interpolation and spatial prediction.	**K5**
CO 5	To assess data and model quality, errors in data.	**K6**

COURSE DESCRIPTOR

Course Code	**PST3ID01**
Course Title	**DATA VISUALIZATION AND MATLAB**
Credits	**2**
Hours/Week	**4**
Category	**INTER DISCIPLINARY (ID) – THEORY**
Semester	**III**
Regulation	**2022**

Course Overview

- This course provides an introduction to MATLAB and Data Visualization using programming software for beginners.
- Python and MATLAB are software package used for computation and visualization in an integrated environment.
- It focuses on skill development in analyzing data for numerous statistical and mathematical problems.
- Topics covered include basic library functions, graphical representations and analytical tools with user defined function.
- The course emphasizes on the applications to real life problems.

Course Objectives

- To impart basic knowledge of MATLAB, Python and Data Visualization for simple problems.
- To familiarize with syntax, semantics, data-types and library functions.
- To develop a top-down, modular and systematic approach for debugging programs.
- To design mathematical structures using various functions.
- To write programs using user defined function to solve real life problems.

Prerequisites	Basic knowledge in computer, statistics and mathematics

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	The introduction to Python programming and various Python packages: Matplotlib, Seaborn, Bokeh, Ploty, differences and importance of packages. Basic concepts of Python, Conditional statements, Python data types and user defined function.	9	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Data visualization: univariate, bivariate and multivariate using the existing packages and advanced effective techniques for data visualization.	9	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Data visualization customization: Decorating graphs with Plot styles and types using user defined function for univariate, bivariate and multivariate.	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Introduction to MATLAB, Vectors and Matrices, Introduction to MATLAB programming Selection statements, Loop statements and Vectorizing code	13	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	MATLAB programs, Advanced plotting techniques, Advanced mathematical Techniques	13	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Molin, S. (2019). Hands-on data analysis with Pandas: Efficiently perform data collection,wrangling, analysis and visualization, Packt Publishing Ltd.
2. Ashwin Pajankar, (2021). Practical python data visualization: A Fast Track Approach tolearning data visualization with Python, Apress, 1st Edition.
3. Attaway, S. (2017). Matlab: A practical introduction to programming and problem solving, Elsevier, Butterworth Heinemann Publication, 4th Edition.

Suggested Readings

1. Yim, A., Chung, C. and Yu, A. (2018). Matplotlib for python developers second edition effective techniques for data visualization with Python, Packt Publishing Ltd.
2. Embarak, O. (2018). Data Analysis and visualization using Python (Analyze data to create visualizations for BI systems), 1st Edition. Apress.
3. Knaflic, C. N. (2015). Storytelling with Data: A Data Visualization Guide for Business Professionals, 1st Edition. Wiley.
4. Palm III, W. J (2018). Introduction to Matlab 7 for Engineers, , McGraw Hill, 4th edition.
5. Baez-Lopez, D. (2010). Matlab with applications to engineering, physics and finance, CRC Press.
6. Yangquan chen, D. X. (2008). Solving Applied Mathematical Problems with MATLAB, CRC Press.
7. Houcque, D. (2005). Introduction to MATLAB for Engineering Students, Northwestern University, ebook.

Web Resources

1. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf
2. https://www.analyticsvidhya.com/blog/2015/07/guide-data-visualization-r/
3. https://statsandr.com/blog/descriptive-statistics-in-r/
4. www.in.mathsworks.com
5. https://www.javatpoint.com/matlab-introduction
6. https://www.geeksforgeeks.org/introduction-to-matlab/

Course Outcomes

Cos	PST3ID01 - Data Visualization and MATLAB (Theory)	Cognitive Level
CO1	To understand the statistical and mathematical library functions of Python and MATLAB.	K1, K2
CO2	To apply programming skills in writing mathematical and statistical scripts.	K3
CO3	To analyze and examine the statistical and mathematical concepts using Python and MATLAB scripts.	K4
CO4	To customize and visualize mathematical structures using data visualization functions.	K5
CO5	To generate Python and MATLAB programs to handle real-life problems	K6

COURSE DESCRIPTOR

Course Code	**PST3ID02**
Course Title	**DATA VISUALIZATION AND MATLAB**
Credits	**1**
Hours/Week	**2**
Category	**INTER DISCIPLINARY (ID) - LAB**
Semester	**III**
Regulations	**2022**

Course Overview

- This course provides an introduction of MATLAB programming software for beginners and Data Visualization using Python software
- Python and MATLAB are software package used for computation and visualization in an integrated environment.
- It focuses on skill development in analyzing data for numerous statistical and mathematical problems.
- Topics include basic library functions, graphical representations and analytical tools with user defined function.
- The course emphasizes on the applications to real life problems.

Course Objectives

- To understand the uses of basic commands.
- To familiarize with syntax, semantics, data-types and library functions.
- To develop a top-down, modular and systematic approach in debugging programs.
- To design statistical and mathematical structures using graphical features.
- To write programs using user defined function to solve real life problems.

Prerequisites	Basic knowledge in Statistics, Mathematics and Computer programming skills

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Setting up the data visualization platform in python and write simple programs using existing packages and user defined function for statistical problems.	4	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Data visualization: Line plot, Scatter plot, multiline plots, scatter plot to show clusters, adding trend line over a scatter plot, bubble chart, Polar chart, Mean-and-error plots, Visualizing multivariate data with a heatmap, Showing hierarchy in multivariate data with clustermap, 3D plots with Axes3D, Geographical plotting	4	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Graphs with plot styles and types: Adjusting axis limits, Adding axis labels, Adding a grid, Adding a title,Adding a legend, Setting the output format, Setting the figure resolution, Drawing Subplots, Controlling the colors, Line and marker styles, Text and annotations, Using style sheets, Aesthetics and readability considerations in styling, Adjusting axes and ticks.	5	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Simple MATLAB programs – Introduction, function file writing, Programs using – selection statements and looping variables	8	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	File handling techniques, Programs using graphical tools	5	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Molin, S. (2019). Hands-on data analysis with Pandas: Efficiently perform data collection, wrangling, analysis and visualization, Packt Publishing Ltd.
2. Ashwin Pajankar, (2021). Practical python data visualization: A Fast Track Approach to learning data visualization with Python, Apress, 1st Edition.
3. Attaway, S. (2017). Matlab: A practical introduction to programming and problem solving, Elsevier, Butterworth Heinemann Publication, 4th Edition.

Suggested Readings

1. Yim, A., Chung, C. and Yu, A. (2018). Matplotlib for python developers second edition effective techniques for data visualization with Python, Packt Publishing Ltd.
2. Embarak, O. (2018). Data Analysis and visualization using Python (Analyze data to create visualizations for BI systems), 1st Edition. Apress.
3. Knaflic, C. N. (2015). Storytelling with Data: A Data Visualization Guide for Business Professionals, 1st Edition. Wiley.
4. Palm III, W. J (2018). Introduction to Matlab 7 for Engineers, , McGraw Hill, 4th edition.
5. Baez-Lopez, D. (2010). Matlab with applications to engineering, physics and finance, CRC Press.
6. Yangquan chen, D. X. (2008). Solving Applied Mathematical Problems with MATLAB, CRC Press.
7. Houcque, D. (2005). Introduction to MATLAB for Engineering Students, Northwestern University, ebook.

Web Resources

1. https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf
2. https://www.analyticsvidhya.com/blog/2015/07/guide-data-visualization-r/
3. https://statsandr.com/blog/descriptive-statistics-in-r/
4. www.in.mathsworks.com
5. https://www.javatpoint.com/matlab-introduction
6. https://www.geeksforgeeks.org/introduction-to-matlab/

Course Outcomes

Cos	**PST3ID02 - Data Visualization and MATLAB – (ID) LAB**	Cognitive Level
CO1	To understand the statistical and mathematical library functions ofPython and MATLAB using practical approach.	K1, K2
CO2	To apply programming skills in writing mathematical and statisticalscripts in Practical.	K3
CO3	To analyze and examine the statistical and mathematical concepts using Python and MATLAB software.	K4
CO4	To customize and visualize mathematical structures using data visualization functions in practical.	K5
CO5	To generate Python and MATLAB programs to handle real-life problemsin practical approach	K6

COURSE DESCRIPTOR

Course Code	**PST3VA01**
Course Title	**APPLIED STATISTICS USING SPSS - LAB**
Credits	**1**
Hours/Week	**2**
Category	**Value Added Course [Open to All]**
Semester	**III**
Regulation	**2022**

Course Objective

- To perform exploratory data analysis using statistical measures and visualizations in SPSS
- To establish statistical significance in testing of hypothesis using SPSS
- To build predictive models for continuous and categorical outcome variables
- To capture information in lower dimension using dimension reduction techniques
- To group data into similar observations / variables using clustering methods.

SYLLABUS	
UNIT	**CONTENT**
I	**Unit 1: Data handling:** open SPSS data file – save – import from other data source – data entry – assign variable value - recode in to same variable – recode in to different variable – transpose of data – insert variables and cases – merge variables and cases – split file.
II	**Unit 2: Basic Statistical Measures and Data Visualizations** Measures of Central tendency and dispersion - Mean, Median, Mode, Percentiles, Deciles, Quartiles, Variance , Standard deviation, Skewness, kurtosis. Tabulation of continuous and categorical variables, Cross tabulations, Data visualization for univariate and bivariate analysis of categorical and continuous variables – Bar chart, Pie chart, Subdivided bar chart, Multiple Bar chart, Scatter plot, Histogram and Box Plot.
III	**Unit 3: Parametric Test** One sample t test, Two sample t test, Paired t test, One way Analysis of Variance, Two Way Analysis of Variance and Post Hoc Multiple comparison test.

IV	**Unit 4: Non – Parametric Test:** One sample Kolmogorov Smirnov test – Mann Whitney U test- Wilcoxon Signed Rank test - Kruskal Wallis test – Friedman test. Chi-square test for independence.
V	**Unit 5: : Correlation and Regression Analysis** Correlation: Karl Pearson's correlation - Spearman's Rank Correlation - Kendall's tau Correlation, Regression: Simple and Multiple Regression Analysis, Binary Logistic Regression Analysis.

Books for Study:

1. Andy Field, 2013), Discovering Statistics using IBM SPSS Statistics,(Sage Publications, 4th Edition
2. Sabine Landau and Brian S. Everitt, (2004), A Handbook of Statistical Analyses Using SPSSCRC Pres, Boca Raton London New York Washington, D.C.

Books for Reference:

1. Keith McCormick and Jesus Salcedo, SPSS Statistics for Data Analysis and Visualization, (2017), Wiley Publications.
2. James O. Aldrich, James B. Cunningham, (2015), Using IBM® SPSS® Statistics: An Interactive Hands-On Approach 2nd edition, SAGE Publications, Inc.

IV SEMESTER

COURSE DESCRIPTOR

Course Code	**PST4MC01**
Course Title	**ADVANCED EXPERIMENTAL DESIGN**
Credits	**07**
Hours/Week	**06**
Category	**MAJOR CORE (MC) – THEORY**
Semester	**IV**
Regulation	**2022**

Course Overview

- To provide both basic and advanced experimental designs applied in Agriculture, Pharmaceutical, Industrial and Biological sciences.
- To derive solutions for statistical inference problems
- To Plan, design and conduct experiments efficiently and effectively.
- Students choose the appropriate design of experiment for the given data.
- Students analyze the resulting data to obtain valid objective conclusions.

Course Objectives

- To understand the basic and advanced concepts in applied experimental designs.
- To help the students ability to deal with Industrial and business problem through design of experiments.
- Obtaining relevant information from the experiment regarding the statistical hypothesis under study
- To develop the knowledge in applied experimental design
- To analyze the resulting data of an experiment, and communicate the results effectively to decision-makers.

Prerequisites	Basic knowledge in estimation theory and testing of hypothesis.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Review of Linear models – Completely Randomized design – Randomized Block Design – Latin Square Design – Repeated Latin Square Design- Graeco - Latin Square Design – Missing plot techniques – ANCOVA.(one way and two way classification with one concomitant variable)	14	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Factorial Design – 2^n; 3^n factorial designs. Finite fields and design of experiments. Partial confounding and complete confounding – confounding in more than two blocks. Fractional factorials – Fold over design - construction and analysis-concept of resolution plans.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Asymmetrical Factorial Designs (AFD) - Confounded Asymmetrical Factorial Design (CAFD) construction of Balanced Confounded Asymmetrical Factorials- 2 stage and m-stage Nested design - split and strip-plot experiment..	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Incomplete block designs – C matrix - criteria for connected design, balanced design and orthogonal design -varietal Trials – incomplete block design balanced Incomplete Block Designs (BIBD) construction of BIBD - analysis of BIBD. Partially Balanced Incomplete Block Design (PBIBD) – analysis and construction of PBIBD - Group divisible –Simple triangular- Latin square type and cyclic PBIBD.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Orthogonal Latin square – maximum number of orthogonal Latin Squares – construction of Mutually Orthogonal Latin Squares (MOLS) – construction of BIBD using orthogonal Latin squares. Response surface designs- definition of response surface design – first order and second order response surface design.	16	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Montgomery, D.C, (2013), Design and Analysis of Experiments, Eighth Edition, John Wiley & Sons.
2. Das M.N. and Giri N., (2017). Design and Analysis of Experiments, Third Edition, New Age International Publishers.
3. Kempthorne, O. and Hinkelmann, K. (2014). Design and analysis of Experiments, Volume 2 (Advanced Experimental Design), Wiley.

SUGGESTED READINGS

1. Joshi, D. D. (1987). Linear Estimation and Design of Experiments, New Age International Private Limited.
2. Dey, A. (1986), Theory of Block Designs, Wiley Eastern.
3. Federer, W. T. (1993). Experimental Design – Theory and Application, Oxford & IBH Publishing Co.

WEB SOURCES

1. **https://cutt.ly/7PDMgMK**
2. **https://cutt.ly/kPDMvkv**
3. **https://cutt.ly/lPDMWca**
4. **https://cutt.ly/3PDMOPU**
5. **https://cutt.ly/uPDME5x**
6. **https://cutt.ly/IPDMCSJ**

Course Outcomes (COs)

PST4MC01 - APPLIED EXPERIMENTAL DESIGN (MC)		Cognitive Level
CO 1	**To understand** the process of applied experimental design including advanced concepts.	**K1, K2**
CO 2	**To Identify** the treatments and response variables and investigate logic of hypothesis.	**K3**
CO 3	**To Analyze** the various experimental design and the detailed analysis of experimental data.	**K4**
CO 4	**To explain** the analysis of variance output and interpret the key factors to influence the response variables and Understand the role of response surface methodology.	**K5**
CO 5	**To Construct** and apply suitable experimental designs in Agriculture, Pharmaceutical, Industrial and Biological sciences.	**K6**

COURSE DESCRIPTOR

Course Code	PST4MC02
Course Title	**BIOSTATISTICS AND SURVIVAL ANALYSIS**
Credits	**06**
Hours/Week	**05**
Category	**MAJOR CORE (MC) – THEORY**
Semester	**IV**
Regulation	**2022**

Course Overview

- This course enables students to gain understanding in various observational study designs and experimental study designs and how its applied in real-life
- Statistical measures and its use in assessing the effectiveness and comparison of diagnostic test procedures
- Fitting of various survival distributions for a given survival data and assessing the goodness of fit
- Plotting survival curves using distribution free methods and testing the difference between the survival curves
- Construction of Cox-Proportional Hazard model, Extended Cox Model, Stratified Cox model and Frailty Models.

Course Objectives

- To understand applications of various study designs and decide on which study design to use for a given scenario.
- To develop the ability to compare diagnostic test procedures using statistical measures.
- To analyse survival data and determine the best fit among a set of potential candidate distributions.
- To obtain visualization of survival curves and test for the difference in survival functions between two or more treatment procedures.
- To construct survival models accounting for effects of factors and covariates for survival data.

Prerequisites	Basic knowledge in Probability theory and Statistical Inference.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Introduction to Medical research – Observational and Experimental Study designs – Case Series study – Case control study – Cohort Study – Cross-sectional study – Clinical trial with independent concurrent control – Clinical trial with self-control – Clinical trial with cross-over – Clinical trial with historical control – Meta analysis - Sample Size Calculation in Medical Research for experimental and observational study designs	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	PPV, NPV, FOR, FDR, TPR, TNR, FNR, FPR, LR+, LR-, DOR, ACC, F1 Score, Determining optimal cut-off in diagnostic tests. Youden's index, Euclidean index, product method - diagnostic odds ratio method. Research questions about mean of one or more groups, proportions in one or more groups. Repeated measures design – Paired comparison of means and proportion.	**10**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Survival Analysis – Survival function - Hazard function- The Exponential Distribution, Weibull Distribution, Lognormal Distribution, Gamma Distribution. Hazard Plotting. Relative, Corrected Survival Rates, Standardised Rates and Ratios.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Kaplan Meier Survival Curve, Life Table Analysis, Comparison of Survival Distribution – Log Rank Test for comparing two groups, Log rank test for comparing n-groups , Cox Proportional Hazard Model, Meaning of Proportional Hazard Assumption.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Time dependent covariates - Extended Cox Model - Evaluation of PH assumption using Graphical and model based approach, Stratified Cox model – Univariate frailty model - Multivariate frailty model - shared frailty model - correlated frailty model.	**15**	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

TEXT BOOKS

1. Kleinbaum, D. G. (1996): Survival Analysis, Springer.
2. Dawson, B. & Robert G. (2001): Basic & Clinical Biostatistics, McGraw-Hill.

SUGGESTED READINGS

1. Lee, E. T. (1992) Statistical Methods for Survival Data Analysis , 2nd Ed, John Wiley and Sons
2. Wayne, W. D. (1995): Biostatistics: A Foundation for Analysis in the Health Sciences – 6th edn. John Wiley & Sons.

WEB SOURCES

1. https://www.cdc.gov/training/publichealth101/epidemiology.html
2. https://www.nidcd.nih.gov/health/statistics/what-epidemiology
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4318396/
4. https://pubmed.ncbi.nlm.nih.gov/24049221/

COURSE OUTCOMES (COs)

PST4MC02 - Biostatistics and Survival Analysis **(MC)**		**Cognitive Levels**
CO 1	To be able to design experimental study to compare diagnostic test procedures using statistical measures	**K1,K2**
CO 2	To analyse and determine the best fit among possible survival distributions and make probability statements based on fitted distribution	**K3**
CO 3	To visualize survival data through plots of survival functions f(t), S(t), h(t) and H(t)	**K4**
CO 4	To use statistical tests for testing the difference between two or more treatment procedures.	**K5**
CO 5	To build statistical models to survival data to predict the survival time, study the effects of factors by adjusting for the effects of covariates.	**K6**

COURSE DESCRIPTOR

Course Code	PST4MC03
Course Title	**Statistics Lab – IV (SAS)**
Credits	**02**
Hours/Week	**04**
Category	**MAJOR CORE (MC) - LAB**
Semester	**IV**
Regulation	**2022**

Course Overview

- This course enables students to gain knowledge in SAS for Statistical Data Analysis
- Data preparation and data management using SAS Programming
- Analysing data from experiments through proc statements in SAS
- Visualization and comparison of treatment procedures using Distribution free methods and Parametric tests
- Construction of Survival models to assess the impact of various factors over survival time after adjusting for the effects of covariates.

Course Objectives

- To understand the basics of SAS programming for data management
- To write SAS program using data step and proc step for analysing data.
- To analyse data from experimental designs using ANOVA and factorial designs.
- To visualize the survival data using survival functions and hazard functions accompanied with statistical tests.
- To study the effect of various factors on the survival time after controlling for the effect of nuisance factors and covariates.

Prerequisites	Basic knowledge in Statistical inference.

SYLLABUS				
UNIT	**CONTENT**	**HOURS**	**Cos**	**COGNITIVE LEVEL**
I	Data Management in **SAS:** Creating dataset using Data lines / Cards statement - Importing and Exporting Datasets in CSV, TXT and MS Excel format - Subsetting dataset using conditional statements - Sorting dataset - Aggregating dataset - Merging datasets (Inner Join, Outer Join, Left Outer Join and Right Outer Join)	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
II	Complete Randomized Design - Randomized Block Design - Latin Square Design - Balanced Incomplete Block Design - Split Plot Design - ANCOVA	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
III	Factorial Design – 2^2 - Factorial Design – 2^3 - Factorial Design – 3^2 - Factorial Design – 3^3 - Randomized Block Design - Response Surface Methodology	10	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
IV	Odds Ratio, Sensitivity and Specificity - Risk Ratios, Mortality Rates and Adjusted Rates - Determination of optimal diagnostic rule for binary classification - Goodness of fit – Survival Distributions - Kaplan-Meier Survival Curves - Log-Rank Test	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6
V	Cox Proportional Hazard Model - Testing PH assumption in Cox PH model using Graphical approach - Extended Cox Model - Testing PH assumption in Cox PH model using Extended Cox Model - Stratified Cox model - Construction of Frailty Model	11	CO1 CO2 CO3 CO4 CO5	K1 K2 K3 K4 K5 K6

Text Books

1. Delwiche, L.D. and Slaughter, S. J. (2002). The Little SAS Book: A Primer, SAS Press,.
2. Allison, P. D. (2010). Survival Analysis Using SAS: A Practical Guide, 2nd Edition, SAS Press.
3. Gamst, G., Meyers, L.S. and Guarino, A. J. (2008). Analysis of Variance Designs: A Conceptual and Computational Approach with SPSS and SAS, Cambridge University Press.

Suggested Readings

1. Cody, R. (2016). Biostatistics by Example Using SAS Studio, SAS Press.
2. Cody, R. (2011). SAS Statistics by Example, SAS Press.
3. Anderson, F. (2019). ANOVA by Example: Hands on Approach Using SAS, SAS Press.

Web Resources

1. https://www.sas.com/en_in/training/home/academic-program/sas-tutorials.html
2. https://www.listendata.com/p/sas-tutorials.html
3. https://www.guru99.com/sas-tutorial.html
4. https://data-flair.training/blogs/sas-tutorial/

Course Outcomes

	PST4MC03 - Statistics Lab – IV (SAS)	Cognitive Level
CO 1	To be able to process data using data step and proc steps in SAS	**KI, K2**
CO 2	To perform ANOVA procedures for Block designs	**K3**
CO 3	To analyse data from factorial experiments and interpret main effects and interaction effects	**K4**
CO 4	To plot survival curves and test the difference between the survival curves	**K5**
CO 5	To construct survival models in determining the effect of treatment on survival time after controlling for the nuisance factors.	**K6**

LOCF BASED DIRECT ASSESSMENTS

COGNITIVE LEVEL (CL) AND COURSE OUTCOME (CO) BASED CIA QUESTION PAPER FORMAT (PG)

SECTION		Q. NO	COGNITIVE LEVEL (CL)					
			K1	K2	K3	K4	K5	K6
A	(5 x 1 = 5) Answer ALL	1(a)	+					
		(b)	+					
		(c)	+					
		(d)	+					
		(e)	+					
	(5 x 1 = 5) Answer ALL	2(a)		+				
		(b)		+				
		(c)		+				
		(d)		+				
		(e)		+				
B	(1 x 8 = 8) Answer 1 out of 2	3			+			
		4			+			
C	(1 x 8 = 8) Answer 1 out of 2	5				+		
		6				+		
D	(1 x 12 = 12) Answer 1 out of 2	7					+	
		8					+	
E	(1 x 12 = 12) Answer 1 out of 2	9						+
		10						+
No. of CL based Questions with Max. marks			5 (5)	5 (5)	1 (8)	1 (8)	1 (12)	1 (12)
No. of CO based Questions with Max. marks			CO1		CO2	CO3	CO4	CO5
			10 (10)		1 (8)	1 (8)	1 (12)	1 (12)

Forms of questions of **Section A** shall be MCQ, Fill in the blanks, True or False, Match the following, Definition, Missing letters. Questions of **Sections B, C, D and E** could be Open Choice/ built in choice/with sub sections. Component III shall be exclusively for cognitive levels K5 and K5 with 20 marks each. CIA shall be conducted for 50 marks with 90 min duration.

COGNITIVE LEVEL (CL) AND COURSE OUTCOME (CO) BASED END SEMESTER EXAMINATION QUESTION PAPER FORMAT (PG)

SECTION		Q. NO	COGNITIVE LEVEL (CL)					
			K1	K2	K3	K4	K5	K6
A	(5 x 1 = 5) Answer ALL	1(a)	+					
		(b)	+					
		(c)	+					
		(d)	+					
		(e)	+					
	(5 x 1 = 5) Answer ALL	2(a)		+				
		(b)		+				
		(c)		+				
		(d)		+				
		(e)		+				
B	(3 x 10 = 30) Answer 3 out of 5	3			+			
		4			+			
		5			+			
		6			+			
		7			+			
C	(2 x 12.5 = 25) Answer 2 out of 4	8				+		
		9				+		
		10				+		
		11				+		
D	(1 x 15 = 15) Answer 1 out of 2	12					+	
		13					+	
E	(1 x 20 = 20) Answer 1 out of 2	14						+
		15						+
No. of CL based Questions with Max. marks			5 (5)	5 (5)	3 (30)	2 (25)	1 (15)	1 (20)
No. of CO based Questions with Max. marks			CO1		CO2	CO3	CO4	CO5
			10 (10)		3 (30)	2 (25)	1 (15)	1 (20)

IMPORTANT

- Forms of questions of **Section A** shall be MCQ, Fill in the blanks, True or False, Match the following, Definition, Missing letters.
- Questions of **Sections B, C, D and E** could be Open Choice/ built in choice/questions with sub divisions.
- Maximum sub divisions in questions of Sections B, C shall be 2 and 4 in Sections D, E).

TOTAL MARKS DISTRIBUTION OF DIRECT ASSESSMENTS BASED ON CL AND CO (PG)

Course Outcome	**CO1**		**CO2**	**CO3**	**CO4**	**CO5**	**TOTAL**
Cognitive Levels	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	
CIA 1	5	5	8	8	12	12	50
CIA 2	5	5	8	8	12	12	50
Comp III	-	-	-	-	20	20	40
Semester	5	5	30	25	15	20	100
Total Marks (CL)	**15 (6%)**	**15 (6%)**	**46 (19%)**	**41 (17%)**	**59 (25%)**	**64 (27%)**	**240**
Total Marks (CO)	**30 (12%)**		**46 (19%)**	**41 (17%)**	**59 (25%)**	**64 (27%)**	**240**