SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
Master of Science in Statistics
MSc (Statistics) Semester: III

Programme Outcome (PO) - For MSc **Statistics** Programme	Master of Science program provides extended theoretical and practical knowledge of different science subjects. Master of Science programme at Sardar Patel University is designed keeping the overall back ground preparation in mind for the student to either seek a job or to become an entrepreneur. The students, after completion of Bachelor of Science can select the master's programme in the subject they have had at the final year or in a related discipline (depending upon eligibility criteria prescribed by university). **Programme outcomes: At the end of the program, the students will be able to** 1. Have a deep understanding of both the theoretical and practical concepts in the respective subject. 2. Understand laboratory processes and use scientific equipments and work independently. 3. Develop research temperament as a consequence of their theory and practical learning. 4. Communicate scientific information in oral and written form. 5. Understand the issues related to nature and environmental contexts and think rationally for sustainable development. 6. The students are able to handle unexpected situations by critically analyzing the problem.
Programme Specific Outcome (PSO) - For MSc **Statistics** Semester - III	1. 2. …

To Pass	At least 40% Marks in the University Examination in each paper and 40% Marks in the aggregate of University and Internal examination in each course of Theory, Practical & 40% Marks in Viva-voce.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total
Core Course	PS03CSTA51	Design and Analysis of Experiments	T	4	3	30	70	100
	PS03CSTA52	Multivariate Analysis	T	4	3	30	70	100
	PS03CSTA53	Practicals	P	4	3	30	70	100
	PS03CSTA54	Practicals	P	4	3	30	70	100
	PS03CSTA55	Comprehensive Viva-Voce	P	1	3	30	70	100
Elective Course	PS03ESTA51	Reliability and Life Testing	T	4	3	30	70	100
	PS03ESTA52	Generallized Linear Models	T	4	3	30	70	100
	PS03ESTA53	Survival Analysis	T	4	3	30	70	100
	PS03ESTA54	Time Series Analysis	T	4	3	30	70	100

(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS03CSTA51	Title of the Course	DESIGN AND ANALYSIS OF EXPERIMENTS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To familiarize the students with the statistical technique viz. Design of Experiments, for planning, designing and analyzing the experiment so that valid information can be drawn effectively and with great efficiency. 2. To familiarize with various methods of designing experiments.

Course Content

Unit	Description	Weightage* (%)
1.	Introduction to designed experiments, General block designs and its information matrix, its criteria for connectedness, balancedness and orthogonality. Intra block analysis and recovery of inter block information for BIBD and PBIBD (2).	25
2.	Galois field, MOLS and Finite Geometries for construction of BIBDs, derived BIBDs. Properties of BIBDs. Construction of You den square design and Row Column design and their analysis	25
3.	Factorial Experiments 2-level and 3-level factorial experiments in randomized blocks. Confounding and fractional factorial experiments.	25
4.	Application Areas Missing plot technique – general theory and application to BIBD. Split plot and split block experiments, Analysis of covariance in general Markov model, Response Surface experimental designs and ANOVA.	25
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Teaching-Learning Methodology	

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage

1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	know how to plan, design and conduct experiments efficiently and effectively using various designs.
2.	make use of the basics of Design of Experiments such as randomization and blocking.
3.	identify common and important types of experimental designs with respective advantages and disadvantages.
4.	perform a correct statistical analysis of different types of designs.

Suggested References:	
Sr. No.	References
1.	Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer.
2.	Petersen, R. G. (1985). Design and Analysis of Experiments, Marcel Dekker, Inc., New York.
3.	Montgomery, D. C. (2001). Design and Analysis of Experiments, Wiley.
4.	Cochran, W. G. and Cox, M. C. (1992). Experimental Designs, 2nd ed., Wiley.
5.	Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis Of Experiments, Vol 1 &2, Wiley
6.	D. G. Kabe, S. M. Shah. Design and Analysis of Expts (Queen's Uni.)
7.	Das, M. N. and Giri, N. C. (1979). Design and Analysis of Experiments, Wiley Eastern Limited, New Delhi
8.	Aloke D. (1986). Theory Of Block Designs, Wiley.
9.	Chakrabarti, M. C. (1970).Mathematics of Design And Analysis Of Experiments, Asia Publishing House

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science) (M. Sc.) (Statistics) Semester (III)

Course Code	PS03CSTA52	Title of the Course	MULTIVARIATE ANALYSIS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To introduced various multivariate distributions, such as multivariate normal, Wishart, Hotelling's T-square and Wilk's lamda. distributions their properties and application in testing of hypotheses 2. To describe various properties of these distributions. 3. To discuss applications of these distributions in testing of hypotheses concerning normal means and covariance matrices.

Course Content		
Unit	Description	Weightage* (%)
1.	Multivariate Normal Distribution (characterization) and its properties. Random sampling from a multivariate normal distribution. Maximum likelihood estimation of parameters, Distribution of the MLEs. Symmetric Multivariate Normal Distribution (SMND). Distribution of sample intra-class correlation coefficient in a random sample from a SMND. Application in testing and interval estimation	25
2.	Wishart matrix, its distribution and properties. Distribution of generalized variance. Wilk's lamda distribution. Null and non-null distribution of simple correlation matrix. Null distribution of partial and multiple correlation coefficients. Application in testing and interval estimation.	25
3.	Distribution of Hotelling's T-square statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of mean vector in a multivariate normal population. Roy's Union-Inter section principle.	25
4.	Test concerning covariance matrices and Test for identical populations of k-independent MNDs Multivariate linear regression model, estimation of parameters, tests of linear hypotheses about regression coefficients using LRT. Multivariate analysis of variance (MANOVA) of one and two way classified data.	25

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	have knowledge of Multivariate Normal Distribution (MND), its properties and be able to estimate the parameters of MND.
2.	know and be able to apply Hotelling's T^2 statistic to test hypotheses concerning Mean of MND.
3.	be able to use LRT principle to construct tests concerning parameters of one and more independent MNDs.
4.	have basic knowledge on MANOVA, Multivariate Regression Analysis (MRA) and inferential problems related to MRA.

Suggested References:	
Sr. No.	References
1.	Anderson, T.W. (1958). Introduction to Multivariate Statistical Analysis, Wiley, NY
2.	Giri, N C. (1977). Multivariate Statistical Inference. Academic press, NY
3.	Kshirsagar, A. M. (1972). Multivariate Analysis, Marcel Dekker,NY
4.	Johnson, R.A. and Wichern, D.W. (1992). Applied Multivariate Statistical Analysis 3rd Ed.,PHI

5.	Mardia, K.V., Kent, J.T., and Bibby, J.M. (1979). Multivariate Analysis, Academic Press, NY
6.	Muirhead, R. J. (1982). Aspect of Multivariate Statistical Theory,Wiley, NY
7.	Rao, C.R.(1973). Linear Statistical Inference and its Applications, 2nd ed. Wiley,NY
8.	Saber, G.A.F.(1984). Multivariate Observations, Wiley, NY
9.	Siotani, M., Hayakawa, T., and Fujikoshi, Y.(1985). Modern Multivariate Analysis

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS02CSTA53	Title of the Course	PRACTICALS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. 2. …

Course Content		
Unit	Description	Weightage* (%)
1.		25
2.		25
3.		25
4.		25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	
2.	
3.	
…	

Suggested References:	
Sr. No.	References
1.	
2.	
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On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS02CSTA54	Title of the Course	PRACTICALS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. 2. …

Course Content		
Unit	Description	Weightage* (%)
1.		25
2.		25
3.		25
4.		25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	
2.	
3.	
…	

Suggested References:	
Sr. No.	References
1.	
2.	
…	

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS02CSTA55	Title of the Course	COMPREHENSIVE VIVA-VOCE
Total Credits of the Course	01	Hours per Week	04

Course Objectives:	1. 2. …

Course Content		
Unit	Description	Weightage* (%)
1.		
2.		
3.		
4.		
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	
2.	
3.	
…	

Suggested References:	
Sr. No.	References
1.	
2.	
…	

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS03ESTA51	Title of the Course	RELIABILITY AND LIFE TESTING
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Concept of attribute and variable in context of reliability. 2. Concept of life model. 3. Classification of life model base on property of hazard rate.

Course Content		
Unit	Description	Weightage* (%)
1.	Reliability concepts, remaining life time, mean time between failure (MTBF), hazard function (HF), bath–shape HF, Reliability in terms of HF. Estimation of parameters and tests in these models. Reliability estimation based on failure times in various censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.	25
2.	Life distribution; reliability function; hazard rate; common life distributions Exponential, Weibull, gamma, Pareto and lognormal distributions.	25
3.	Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components	25
4.	Bayes estimator, for exponential, negative exponential, Weibull and normal life model. Estimation of survival function-Actuarial Estimator, Kaplan-Meier Estimator; Properties of K-M estimator;	25

Teaching-Learning Methodology	On-line/off-line lecture

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage

1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Ability to address problem concerning variable reliability and attribute variability.
2.	Able to classify life model depending on hazard rate.
3.	Dell structure in series arrangement of minimal cut and parallel arrangement of minimal path
4	Can compute bound on reliability by varies methods.

Suggested References:	
Sr. No.	References
1.	Harry F. M. and Ray A. W., (1991). Bayesian reliability analysis, Malabar, Fla. : Krieger.
2.	Lee J. B., (1991). Statistical analysis of reliability and life-testing models, CRC Press.
3.	Lee J. B. and Max E., (1991). Statistical analysis of reliability and life-testing models, Marcel Dekker, New York,
4.	Sheldon M. R., (2000). Life-testing and reliability estimation, Academic press.
5.	Richard E. B. and Frank P. (1981). Statistical theory of reliability and life testing, Silver Spring.
6.	Sinha, S. K. and Kale, B. K. (1980). Life-testing and reliability estimation. New York , Wiley,
7.	Rupert G. Miller, JR, Gail Gong and Alvaro Munoz, (1981). Survival Analysis, Johan Wiley & son, Canada

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS03ESTA52	Title of the Course	GENERALIZED LINEAR MODELS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	To introduce the theory of generalized linear models (GLIM), estimation and testing procedure and explain procedure for fitting of Genralized Linear Models for real data.

Course Content		
Unit	Description	Weightage* (%)
1.	Review of Linear Statistical Models, Discrete Response Data, Introduction of Generalized Linear Models (GLMs), Components: Linear Predictor, Link Function, Natural Parameters, Scale Parameters; Exponential Family of Distributions (EFD): Members of EFD: Normal, Lognormal, Exponential, Gamma, Binomial, Poisson, Negative Binomial; Steps for Model Fitting, Mean and Variance of EFD; Frequent Inference: Estimation of Parameters through Iteratively Reweighted Least Square (IRLS) and Algorithms, Form of Adjacent Dependent Variable and Weights, Analysis of Deviance, Nested Model and Non-Nested Model; Goodness of Fit Criteria: RSquare, Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Bayesian Information Criterion (BIC); Step Wise Selection; Testing of Parameters through Wald Test; Confidence Intervals; GLMs Residuals: Residual Analysis, Pearson Residual, Anscombe Residual, Deviance Residual. Model Checking: Hat Matrix, Outlier, Leverage, Influence	25
2.	Binary Data: Models for Binary Data: Group Data and Ungroup Data, Linear Predictor, Link Function: Logit, Probit and Complementary Log Log; Prospective Study and Retrospective Study, Likelihood Function, Estimation of Parameters through IRLS Method; Deviance; Probit Model, Residual Analysis Polytomous Data: Introduction of Multinomial Logistic Regression and Ordinal Regression, Examples and their inference. Ordinal Regression	25

	Models with Qualitative or/and Quantitative Covariates; Parallel Line Regression	
3.	Count Data: Introduction Poisson Regression, Likelihood, Estimation and Testing of Parameters: Log Linear Model for Contingency Table and their Analysis Generalized Linear Models with distribution having Constant Coefficient of Variation; Gamma Family; Canonical Link Function; Inference and Residual Analysis of GLMs with Gamma Distribution; Comparison between Response having Gamma distribution and lognormal distribution; Examples and Applications	25
4.	Models for Survival Data: Estimation with Censored Survival Data and Survival Distribution: Exponential Distribution; Weibull Distribution and their Examples. Under and Over Dispersion Problem of Data, Quasi Likelihood for Estimation of Parameters, Properties of Quasi Likelihood, Analysis of Deviance; Quasi Likelihood: Binomial, Poisson, Normal, Gamma, Lognormal, Exponential; Comparison of Quasi Likelihood with Likelihood; Concept of Marginal Likelihood, Conditional Likelihood; Models with Nonlinear Parameters in Covariates; Model Checking: Checking Link Function, Checking Covariance Scale, Checking the Variance Function, Score Test for Extra Parameters, Checking Form of Covariates, Detection of Influential Observations	25

Teaching-Learning Methodology	Discussion and question answers based learning Black board/Multimedia projector using ICT Tools Learning through Problem solving approach Assignments and seminars are given for development of confidence among students Fitting of various models to data using software (demonstration of software R language for data handling)

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage

1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the differences between Linear model and generalized model and their underlying assumptions.
2.	Various estimation procedures for estimation of parameters of different generalized models.
3.	know Logit, Probit for binary data and their applications

Suggested References:	
Sr. No.	References
1.	Agresti, A. (2002). Categorical Data Analysis, ED.II, Wiley InterScience
2.	Fahrmier,L .and Tutz,G.(2001). Multivariate Statistical Modeling Based on Generalizes Linear Models, Springer
3.	Gill, J.(2001).Generalized Linear Models: A Unified Approach, Sage Publication
4.	Lindsey, J.K. (1997). Applying Generalized Linear Models , Springer
5.	Maindonald,J. And Braun,J. (2007). Data Analysis and Graphics using R: An example based approach Ed.II, Cambridge University Press
6.	McCullagh, P. And Nelder,J.A. (1983). Generalized Linear Models- Monographs on Statistics and Applied Probability, Chapman and Hall
7.	Myers, R.H, Montegomery, D.C., Vinning, G.G and Robinson, T.J.(2010). Generalized Linear Models with Applications in Engineering and the Sciences, Ed.II , Wiley Series in Probability and Statistics, A John Wiley & Sons.

8.	Agresti, A. (2002). Categorical Data Analysis, ED.II, Wiley InterScience
9.	Fahrmier,L .and Tutz,G.(2001). Multivariate Statistical Modeling Based on Generalizes Linear Models, Springer
10.	Gill, J.(2001).Generalized Linear Models: A Unified Approach, Sage Publication

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS03ESTA53	Title of the Course	SURVIVAL ANALYSIS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Survival analysis involves the analysis of time-to-event data and is widely used in health and medicine. The objective of this course is introducing the fundamental concepts of survival analysis and basic principles such as censoring, survival and hazard functions, Cox proportional hazards regression, model diagnostics and model extensions to incorporate recurrent events and competing risks. 2. To introduce various frailty models.

Course Content		
Unit	Description	Weightage* (%)
1.	Survival data, Concepts of time, order and random and hybrid censoring, Life distributions - exponential, gamma, Lognormal, Pareto, linear failure rate, Ageing classes - IFR, IFRA, NBU, NBUE, HNBUE and their duals, Bathtub failure rate. Parametric inference, point estimation, confidence Intervals, scores, tests based on LR, MLE	25
2.	Life tables, failure rate, mean residual life and their elementary properties. Estimation of survival function - Actuarial estimator, Kaplan - Meier estimator, Estimation under the assumption of IFR/DFR	25
3.	Semi-parametric regression for failure rate - Cox's proportional hazards model, partial likelihood, estimation and inference methods for the Cox models, time-dependent covariates, residuals and model diagnosis, functional forms of the Cox models, goodness-of-fit tests for the Cox models, Competing risk models, Repair models, Probabilistic models, Joint distribution of failure times Unconditional tests for the time truncated case, Tests for exponentiality, two sample nonparametric problem.	25
4.	Nelson-Aalen estimators, counting processes and martingales, modeling counting processes, Regression models for modeling multiple events, Frailty models, Shared frailty models, Identifiability of frailty models, Frailty regression models, Bivariate and correlated frailty models, Additive frailty models.	25
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Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	decide the type of censoring and truncation that is the basis for given survival data
2.	estimate survival functions using parametric and non-parametric methods
3.	construct a life table using the Kaplan-Meier approach
4.	interpret coefficients in Cox proportional hazards regression analysis
5.	compare survival functions of two or more populations; use software for survival analysis
6.	Explain theoretical concepts underlying parametric survival models; and
7.	analyse survival data using basic parametric models and interpret the results

Suggested References:	
Sr. No.	References
1.	Klein, J. P. and Moeschberger, M. L. (1997). Survival Analysis: Techniques for Censored and Truncated Data , Springer, New York
2.	Collett, D. (2003). Modelling Survivaldata in Medical Research, Second Edition, Chapman & Hall/CRC

3.	Therneau, T. M. and Grambsch, P. M. (2000). Modeling Survival Data, Extending the Cox Model, Springer, New York.
4.	Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
5.	Deshpande, J.V. and Purohit, S.G. (2005). Life Time Data: Statistical Models and Methods, Word Scientific.
6.	Duchateau, L. and Johnson, P. (2008). The Frailty Model. Springer: New York.
7.	Hanagal, D. D. (2011). Modeling Survival Data Using Frailty Models. CRC Press.
8.	Kalbfleish, JD. and Prentice, RL. (2002). The Statistical Analysis of Failure Time Data. New York: Wiley.
9.	Hougaard, P. (2000). Analysis of Multivariate Survival Data. Springer: New York.
10.	Wienke, A. (2011). Frailty Models in Survival Analysis, CRC Press: New York.

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (III)

Course Code	PS03ESTA54	Title of the Course	TIME SERIES ANALYSIS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. The objective of this course is to equip students with various forecasting techniques and knowledge on modern statistical methods for analyzing time series data. 2. Introduction of Time Series Models.

Course Content		
Unit	Description	Weightage* (%)
1.	Exploratory time series analysis, tests for trend and seasonality. Exponential and Moving average smoothing. Holt -Winters smoothing. Forecasting based on smoothing, adaptive smoothing. Time - series as a discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties, Portmanteau tests for noise sequences, transformation to obtain Gaussian series.	25
2.	Stationary processes: General linear processes, moving average (MA), auto regressive (AR), and autoregressive moving average (ARMA), Stationarity and invertibility conditions. Nonstationary 29 and seasonal time series models: Auto regressive integrated moving average (ARIMA) models, Seasonal ARIMA (SARIMA) models, Transfer function models (Time series regression).	25
3.	Forecasting in time series models, Durbin-Levinson algorithm, innovation algorithm (without proof), Estimation of mean, auto covariance and autocorrelation functions, Yule-Walker estimation, Estimation of ARIMA model parameters, maximum likelihood method, large sample theory (without proofs). Choice of AR and MA periods, FPE, AIC, BIC, residual analysis and diagnostic checking, Unit-root non stationarity, unit-root tests	25
4.	Multivariate Time series model, VAR models, Vector ARMA models. Conditional heteroschedastic models, ARCH and GARCH, properties, examples, estimation & forecasting, extensions of ARCH & GARCH to asymmetric models. Count time series models, INAR models, Poisson INAR models	25

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Teaching-Learning Methodology	Lecture, Question & Answer, Problem Solving.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	know various components and structures of time series
2.	apply various smoothing techniques
3.	classify various models such as AR, MA, ARMA, ARIMA models and interpret
4.	do ACF and PACF, residual analysis and diagnostic checking, and test and interpret hypothesis about unit root
5.	extend univariate time series models to multivariate time series models

Suggested References:	
Sr. No.	References
1.	Brockwell, P.J. and Davis, R. A. (2003). Introduction to Time Series Analysis, Springer
2.	Chatfield, C. (2001). Time Series Forecasting, Chapman &Hall.

3.	Fuller, W. A. (1996). Introduction to Statistical Time Series, 2nd Ed. Wiley.
4.	Hamilton N. Y. (1994). Time Series Analysis, Princeton University press.
5.	Lutkepohl, H. (2005). New Introduction to Multiple Time Series Analysis, Springer
6.	Shumway, R. H. and Stoffer, D. S. (2010). Time Series Analysis & Its Applications, Springer.
7.	Tsay, R. S. (2010). Analysis of Financial Time Series, Wiley.

On-line resources to be used if available as reference material
On-line Resources

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SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
Master of Science in Statistics
MSc (Statistics) Semester: IV

Programme Outcome (PO) - For MSc **Statistics** Programme	Master of Science program provides extended theoretical and practical knowledge of different science subjects. Master of Science programme at Sardar Patel University is designed keeping the overall back ground preparation in mind for the student to either seek a job or to become an entrepreneur. The students, after completion of Bachelor of Science can select the master's programme in the subject they have had at the final year or in a related discipline (depending upon eligibility criteria prescribed by university). **Programme outcomes: At the end of the program, the students will be able to** 1. Have a deep understanding of both the theoretical and practical concepts in the respective subject. 2. Understand laboratory processes and use scientific equipments and work independently. 3. Develop research temperament as a consequence of their theory and practical learning. 4. Communicate scientific information in oral and written form. 5. Understand the issues related to nature and environmental contexts and think rationally for sustainable development. 6. The students are able to handle unexpected situations by critically analyzing the problem.
Programme Specific Outcome (PSO) - For MSc **Statistics** Semester - IV	1. 2. …

To Pass	At least 40% Marks in the University Examination in each paper and 40% Marks in the aggregate of University and Internal examination in each course of Theory, Practical & 40% Marks in Viva-voce.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total
Core Course	PS04CSTA51	Computer Oriented Statistical Methods	T	4	3	30	70	100
	PS04CSTA52	Statistical Quality Control Techniques	T	4	3	30	70	100
	PS04CSTA53	Practicals	P	4	3	30	70	100
	PS04CSTA54	Project Work	P	1	3	30	70	100
Elective Course	PS04ESTA51	Econometrics and Time Series Analysis	T	4	3	30	70	100
	PS04ESTA52	Actuarial Statistics	T	4	3	30	70	100
	PS04ESTA53	Bioassays	T	4	3	30	70	100
	PS04ESTA54	Clinical Trials	T	4	3	30	70	100

(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04CSTA51	Title of the Course	COMPUTER ORIENTED STATISTICAL METHODS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Develop understanding of generating samples from a specified distribution as input to a simulation model.
	2. Illustrate some widely-used techniques for generating random variates: Inverse-transform technique, Acceptance-rejection technique, Special properties.
	3. To introduce various multivarite techniques for reduction and extraction of multivariate data.
	4. To study interdependency and inter-relationship among the variables.

Course Content		
Unit	Description	Weightage* (%)
1.	Generation of Random Numbers From Uniform, Binomoial, Poisson, Exponential, Weibull, Normal, Gamma, T, F, Multivariate Normal Distribution and Different Stochastic Processes Using Pseudo Random Number Generation Algorithms Like Linear Congruential Method (Lcg), Inverse Method, Rejection Method, etc.	25
2.	Simulation Principles: Rejection Method; Variance Reduction; Importance Sampling. Simulation of Probability Distribution of Different Statistics Using Monte Carlo and Similar Techniques. Estimation of Bias, MSE and other Statistics using Bootstrap and Similar Techniques. MCMC Algorithms: Metropolis-Hastings Algorithm; Gibbs Sampling.	25
3.	Logistic Regression Models: Introduction; The Multiple Logistic Regression Model; Fitting The Logistic Regression Model; Testing for The Significance of The Model. Application of Logistic Regression in study of Matched Case Control Data. Cox's Regression Model:	25

	Proportional Hazard Model. Estimation and tests of parameters of the proportional Hazard Model. Use of this in comparison of two or more life distributions. Discriminant analysis.	
4.	Multivariate Techniques: (I) Principal Component Analysis (II) Factor Analysis (III) Canonical Correlation (IV) Cluster Analysis.	25

Teaching-Learning Methodology	Discussion and question answers based learning Black board/Multimedia projector using ICT Tools Learning through Problem solving approach Assignments and seminars are given for development of confidence among students

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	generate random variables or samples using various methods of random variable generation
2.	know various methods for simulation
3.	use appropriate multivariate technique for data analysis depending of objectives

Suggested References:	
Sr. No.	References

1.	Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Ed. IV, Wiley
2.	Bhuyan, K.C. (2004). Multivariate Analysis and its Applications, New Central Book Agency
3.	Efron, B. and Tibshirani. R.J. (1993); An Introduction to the Bootstrap, Chapman and Hall.
4.	Gemerman, D. and Lopes, H.F. (2006). Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Ed. II, Chapman and Hall
5.	Hair, J. F., Black, W.C., Babin, B. J., Anderson, R.E. and Tatham, R. L. (2006). Multivariate Data Analysis, Ed, VI, Pearson Education
6.	Hardle, W. and Simar, L. (2007) Applied Multivariate Statistical Analysis, Springer
7.	Johnson, R. A. and Wichern, D. W. (2007). Applied Multivariate Statistical Analysis, Prentice-Hall International
8.	Kroese, D. P., Taimre, T. and Botev, Z. I. (2011). Handbook of Monte Carlo Method, Wiley
9.	Manly, B.F. and Navarro Alberto, J.A. (2017). Multivariate Statistical Methods, Ed. IV, CRC Press
10.	McLachlan, G.J. and Krishnan, T. (1997) The EM Algorithms and Extensions.(Wiley.)

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04CSTA52	Title of the Course	STATISTICAL QUALITY CONTROL TECHNIQUES
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	The goal of this course is to introduce statistical quality control (SQC) emphasizing various aspects which are relevant for SQC's practical implementation

Course Content		
Unit	Description	Weightage* (%)
1.	Basic Concepts of quality control. Process control and process capability. Relation between theory of testing hypotheses and charts. choice of control limits, rational subgroup principle, allocating sampling effort, average run length. Purpose of capability Indices. Determining the process capability using, , charts. The role of normality in determining defective parts per million. One sided specification, non-normal distributions.	25
2.	Process capability analysis: potential capability, actual capability, definitive analysis. Testing of potential capability, confidence interval of potential capability and actual capability. Gage and measurement system capability study. Setting specification limits on discret components (linear and non linear combination). Estimation of natural tolerance limit of a process.	25
3.	CUSUM charts, EWMA chart –Use of these charts for prediction. CUSUM, EWMA for controlling process variability. Comparison of these charts with Shewart charts. Acceptance control charts Acceptance sampling plan, chain sampling, continuous sampling plans, Skip –lot sampling plans. Fundamental of experimental design, one factor, two factor, blocking. Concept of interaction.	25
4.	Process Design and Improvement with designed experiments. Use of Design of 2k- factorial design with $k \geq 1$. 2k-p fractional factorial design in SPC. Taguchi's contribution to Quality Engineering. Elements and principle of quality engineering. Steps in robust design; signal to noise ratio.	25
...		

Teaching-Learning Methodology	On-line/off-line lectures.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Can address conformance and impotence on target in context of societal loss.
2.	Use control chart capable to detect shift of magnitude of $L\sigma$; $L \leq 3\sigma$.
3.	Can apply design of experiment to improve process.
4.	Can perform potential capability, actual capability, definitive analysis.
5.	Can practice gage and measurement system capability study.

Suggested References:	
Sr. No.	References
1.	Montgomery, D. C. (1985) Introduction to Statistical Quality Control.(Wiley).
2.	Montgomery, D.C. (1985) Design and Analysis of Experiments; Wiley.
3.	Rayon,T.P(1989) Statistical Methods for quality improvement.John Wiley and sons.
4.	Ott, E.R. (1975) Process Quality Control; McGraw Hill.

5.	Wetherill, G.B. (1977) Sampling Inspection and Quality Control; Halsted Press.
6.	Wetherill, G.B. and Brown, D.W. (1991) Statistical Process Control, Theory and Practice;Chapman and Hall.
7.	Phadke, M.S. (1989) Quality Engineering through Robust Design; Prentice Hall.

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04CSTA53	Title of the Course	PRACTICALS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. 2. …

Course Content		
Unit	Description	Weightage* (%)
1.		25
2.		25
3.		25
4.		25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	
2.	
3.	
…	

Suggested References:	
Sr. No.	References
1.	
2.	
…	

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04CSTA54	Title of the Course	PROJECT
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	1. 2. …

Course Content		
Unit	Description	Weightage* (%)
1.		25
2.		25
3.		25
4.		25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Project Presentation	30%
2.	Project Reports and Presentation	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	
2.	
3.	
…	

Suggested References:	
Sr. No.	References
1.	
2.	
…	

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science) (M. Sc.) (Statistics) Semester (IV)

Course Code	PS04ESTA51	Title of the Course	ECONOMETRICS AND TIME SERIES ANALYSIS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Students have concise knowledge of basic regression analysis so that they are able to understand its applications in different fields in economics. 2. To provide students with some useful tools of econometrics which help in analysis of economic data. 3. To equip students with various forecasting techniques and knowledge on modern statistical methods for analyzing time series data

Course Content		
Unit	Description	Weightage* (%)
1.	Econometrics: Definition, Methodology, Examples, Nature and Source of Data; Classical Linear Regression Model (CLRM): Assumptions, estimation of parameters through Maximum Likelihood Method and Ordinary Least Square Method, Properties of Estimator; Testing of Hypothesis and confidence intervals, Testing of Subset of Regressors, Point Predictor, Model Selection Criterion; R^2, AdjR^2, AIC, BIC Mallow's C_p Statistic; Significance Test and Confidence Interval; Dummy Variable: Nature, introduction, examples, Chow Test, Seasonal Adjustment	25
2.	Hetroscedasticity: Reason of Hetroscedasticity; Consequences of using OLS in presence of Hetroscedasticity; Detection: Informal Method, Formal Method; Park Test, Goldfield-Quant Test; Remedial Measures, Method of Generalized Least Squares (GLS), Autocorrelation: Nature of the Problem, Consequences of Autocorrelation, Detection: Graphical Method; Durbin-Watson d Test, A General Test of Autocorrelation, The Breusch-Goldfrey (BG) Test; GLS when correlation coefficient is known as well as unknown;	25

3.	Multicolinearity Problem, Its implications and tools for handling the problem; Detection of Multicolinearity; Remedial Measures; Ridge Regression; Use of Principle Component Analysis; Introduction to Simultaneous Equation Models; The identification Problem	25
4.	Introduction to Time Series Analysis; Some Basic Concepts: white noise, stationary, non stationary time series, ACF and PACF plot; Unit Root Test (Augmented Dickey-Fuller Test); Forecasting: Exponential Smoothing Methods, AR Process, MA Process, ARMA Process, ARIMA Process; The Box-Jenkins (BJ) Methodology; VAR Model; Auto Regressive Conditional Hetroscedasticity (ARCH) and Generalized Autoregressive Conditional Hetroscedasticity (GARH) Model;	25

Teaching-Learning Methodology	Discussion and question answers based learning Black board/Multimedia projector using ICT Tools Learning through Problem solving approach Assignments and seminars are given for development of confidence among students

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	to specify assumptions, formulate and estimate appropriate models, interpret the results and test their statistical significance.

2.	explain core concepts and techniques in econometrics with special focus on the classical linear regression model.
3.	understand the assumptions upon which different econometric methods are based and their implications.
4.	distinguish regression analysis model and time series model.
5.	understand various components of time series and various time series models.

Suggested References:

Sr. No.	References
1.	Cameron, A.C. and Trivedi, P.K. (2005). Microeconometrics Methods and Applications, Cambridge University Press
2.	Cooray,T.M.J.A. (2008). Applied Time Series Analysis and Forecasting, Narosa Publishing House, New Delhi
3.	Green, W. H. (1993). Econometric Analysis, Ed. II, MACMILLAN Publishing
4.	Greene, W.H. (2003) Econometric Analysis. Ed. V, Pearson Education
5.	Gourieroux, C and Jasiak, J. (2007). Financial Econometrics: Problems, Models and Methods, New Age International
6.	Gujarathi, D.N., Porter, D.C. and Sangeetha (2012). Basic Econometrics, Ed. V , Tata MacGraw Hill, New Delhi
7.	Johnston, J. and Dinardo, J (1997). Econometric methods, Ed. IV, McGraw Hill
8.	Ruppert, D.(2004). Statistics and Finance: An Introduction , Springer (India) Pvt. Ltd.
9.	Shumway, R.H. (1988). Applied Statistical time Series Analysis, Prentice Hall , New Jersey
10.	Theil, H. (1982) : Introduction to the theory and practice of Econometrics, John Wiley.

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04ESTA52	Title of the Course	ACTUARIAL STATISTICS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To introduce various calculations related to finance. 2. To introduce certain statistical concepts exclusively used in the design insurance related instruments. 3. To make aware about reliability and survival analysis concepts being used in insurance sector. 4. To discuss in detail difference lifer insurance policies and annuities.

Course Content		
Unit	Description	Weightage* (%)
1.	Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.	25
2.	Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.	25
3.	Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Life insurance: Insurance payable at the moment's of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, commutation functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportion able annuities-due.	25

4.	Net Premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportion able or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions. Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.	25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	calculations related to lifer insurance policies and finance.
2.	know statistical concepts exclusively used in the design insurance related instruments.
3.	know reliability and survival analysis concepts being used in insurance sector.

Suggested References:	
Sr. No.	References
1.	Deshmukh, S. R. (2009). Actuarial Statistics: An Introduction using R. University Press Pvt. Ltd Hyderabad (Text Book).
2.	. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones D. A. and Nesbitt, C. J. (1986). Actuarial Mathematics', Society of Actuaries, Itasca, III inois, U. S. A. Second Edition (1997) Section I – Chapters: 1, 2, 3, 8, 9, and 11, Section II – Chapters: 4, 5, 6, 7, 13, and 14
3.	Spurgeon E. T. (1972), Life Contingencies, Cambridge University Press.
4.	Neill, A. (1977). Life Contingencies, Heinemann

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04ESTA53	Title of the Course	BIOASSAYS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Explain different types of assays and related statistical concept 2. Introduce bioassays with different designed experiments 3. Complete training on different measures related to bioassays and their use. 4. Do some practical on bioassays with real data sets.

Course Content		
Unit	Description	Weightage* (%)
1.	Principles of planning an assay. Types of biological assays: Direct assays; Ratio estimators, asymptotic distributions; Fieller's theorem . Quantitative dose response relations: Indirect Assays; the dose response regressions; similarity; Assay validity; Monotony; Linearizing transformations; Essential non-linear relation; a response curve for vitamin B12; Homoscedasticity of variance.	25
2.	Parallel line Assays: Asymmetric designs; Complete Analysis; Symmetric dose structure for parallel assays; complete analysis.	25
3.	Slope ratio Assays Quantal responses; The use of quantal responses; minimal effective dose; median effective dose; Methods of estimation of parameters; Estimation of extreme quantiles; Dose allocation schemes; Polychotomous quantal response; Estimation of points on the quantal response function.	25
4.	Estimation of safe doses Bayesian approach to bioassay: Safe dose definition, maximum likelihood estimation of parameters, point estimation and confidence interval for safe doses; Bayesian Bioassay, Bayes binomial estimators, Bayes estimator of the median effective dose.	25
...		

Teaching-Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	understand different types of assays and related statistical concept
2.	distinguish qualitative and quantitative, direct and indirect bioassays
3.	estimate the safe doses.
…	

Suggested References:	
Sr. No.	References
1.	Govindarajulu, Z. (2000). Statistical Techniques in Bioassay, S. Kargar.
2.	Finney, D. J. (1971). Statistical Method in Bioassay, Griffin.
3.	Finney, D. J. (1971). Probit Analysis (3rd Ed.), Griffin.
4.	Weatherile, G. B. (1966). Sequential Methodsin Statistics, Methuen

On-line resources to be used if available as reference material
On-line Resources

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(Mater of Science in Statistics) (Master of Science)
(M. Sc.) (Statistics) Semester (IV)

Course Code	PS04ESTA54	Title of the Course	CLINICAL TRIALS
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To gain knowledge of bio-statistics techniques used in design and analysis of Clinical trials 2. To train in analysis of commonly conducted pharmaceutical clinical trials 3. To learn some novel contemporary statistical designs, statistical tests and statistical analysis techniques used in clinical trials

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction to clinical trials, the need, ethics, protocol of clinical trials, Overview of phase 1 – IV and DF, SE, CTE trials, data management and case studies. Bias and random error in clinical studies, Endpoints of clinical trials and sample size estimation in SE and CTE trials	25
2.	Design of clinical trials parallel vs. cross over designs, cross sectional vs. longitudinal designs, review of factorial designs. Randomization techniques for group allocation.	25
3.	Analysis of outcomes from Phase I- III trials, analysis of survival data from clinical trials, techniques for Interim analysis, intent to treat analysis.	25
4.	Application areas Meta analysis, Multi-center trials, Bioequivalence trials	25

Teaching-Learning Methodology	Interactive Class Lectures, ICT Tools, Problem solving and Group Seminar.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learnerwill be able to	
1.	Writing and understanding CT protocol. Understand, differentiate and identify among four Phases of a complete Clinical Trial
2.	Understand study design of published clinical trial. Make choice and carry out randomized allocation of two treatments as specified. Execute clinical trial as per the experimental design.
3.	Given the clinical trial objective and response type, understand the sample size estimation routine or formula and apply to calculate it.
4.	Perform analysis of survival clinical trials, meta-analysis for systematic review of published clinical trials, interim analysis of trials employing group sequential testing.

Suggested References:	
Sr. No.	References
1.	Shein-Chung Chow and Jen-Pei Liu (2014). Design and Analysis of Clinical Trials, Concepts and Methodologies, 3rd ed., John Wiley
2.	Millard, S. P. and Krause, A. (2010). Applied Statistics in the Pharmaceutical Industry with Case Studies using S-plus, Springer Verlag New York
3.	Senn, S (2002). Cross – Over Trials in Clinical Research, 2nd ed., Statistics in Practice, John Wiley
4.	Jones, B. and Kenward, M. G. (2014). Design and Analysis of Cross-Over Trials, 3rd

	ed. CRC press
5.	Mike W.-L. Cheung (2015). Meta – Analysis, A Structural Equation Modeling Approach, John Wiley
6.	Piantadosi, S. (2005). Clinical Trials –A Methodological Perspective 3rd ed. Wiley.
7.	Mallinckrodt, C. and Lipkovich, I. (2017). Analyzing Longitudinal Clinical Trial Data, A practical guide, CRC Press, T&F G
8.	Molenberghs, G. and Kenward, M. G. (2007). Missing Data in Clinical Studies, Statistics in Practice, John Wiley
9.	Peace, K. E. (2009). Design and Analysis of Clinical Trials with Time-to-Event Endpoints (Edited), CRC Press, T&F G
10.	Pong, A. and Shein—Chung Chow (2011). Handbook of Adaptive Designs in Pharmaceutical and Clinical Development (Edited), CRC Press T&F G
11.	Atkinson, A. C. and Biswas, A. (2014). Randomised Response-Adaptive Designs in Clinical Trials, Monograph on Statistics and Applied Probability, CRC Press, T&F G

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