Shri Swami Vivekanand Shikshan Sanstha

Vivekanand College Kolhapur (Autonomous)

Department of Statistics

M. Sc. Part II-Statistics

Semester III & IV

Syllabus to be implemented from
Academic year 2023-24

Objectives:

1.The students are expected to understand the principles, concepts, and recent developments in the Statistics.

2. To enhance student sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportive environment.

3. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in Statistics.

Program Outcomes (PO):

On successful completion of the program students will able to:

PO1: Understand the principles and concepts in the statistical theory at an advanced level which take into account recent advances in the subject.

PO2: Acquire the strong foundation of statistical concepts which will benefit them to become good Statistician.

PO3: Use acquired statistical methodologies and modelling techniques to address real-life problems.

PO4: Gain the knowledge of software which has the wide range of opportunities in the Quality control, Planning and development, IT sector, industries, Business, Government and private sector etc.

PO5: Qualify various National / State level competitive exams like ISS, DSO, CSIR-UGC NET, SET, GATE, MPSC, UPSC, Banking etc.

Program Specific Outcomes (PSO):

On successful completion of the program students will able to:

PSO1: Enhance sense of enthusiasm for Statistics and to involve them in an intellectually stimulating experience of learning in a supportive environment.

PSO2: Handle and analyse small as well as large databases with computer skills.

PSO3: Understand, implement and develop statistical models.

PSO4: Describe complex statistical ideas to non-statisticians and to present the results of their analyses in written, oral forms and can make practical suggestions for improvement.

PSO5: Apply statistical techniques to optimize and monitor real life phenomena related to industry and business analytics etc.

FEATURES OF DEPARTMENT:

1) **Library:**

Reference and Textbooks, Journals and Periodicals,

2) **Equipment's in Laboratory:**

32 Computers, LCD Projector, Visualizer, Smart board etc.

3) Laboratory Software's:

1) R Software 2) Python

1. **Title:** M. Sc. (Statistics)
2. **Year of Implementation:** The syllabus will be implemented from June, 2022-23 onwards.
3. **Duration:** Two Years
4. **Pattern:** M. Sc. Statistics program has semester pattern and Choice Based Credit System. The program consists of 96 credits.
5. **Medium of instruction:** English

6. Structure of course:

1	CC	Core Course
2	CCS	Core Course Specialization
3	CCPR	Core Course Practical
4	DSE	Discipline Specific Elective

Course	No. of course	Credit per Course	Total Credit	% of Credit
CC	14	4	56	58.33
CCS	4	4	16	16.67
DSE CCPR	2	4	8	8.33
	4	4	16	16.67
	24		96	100

M.Sc. (Statistics) Semester – III

Course Code	Title of the course	Instruction Hrs/week	Marks- End Semester Exam	Marks- Internal Assessment	Credits
CC-2312A	Asymptotic Inference	4	80	20	4
CC-2313A	Multivariate Analysis	4	80	20	4
CC-2314A	Stochastic Processes	4	80	20	4
CC-2315A	Data Mining	4	80	20	4
CC-2316A	Time Series Analysis	4	80	20	4
CCPR-2317A	Practical-III	12	100	--	4
Total Credits of Sem-III					**24**

M.Sc. (Statistics) Semester – IV

Course Code	Title of the course	Instruction Hrs./week	Marks- End Semester Exam	Marks- Internal Assessment	Credits
CC-2318B	Generalized Linear Models	4	80	20	4
CC-2319B	Survival Analysis	4	80	20	4
CC-2320B	Biostatistics	4	80	20	4
CC-2321B	Optimization Techniques	4	80	20	4
CC-2322B	Statistical Quality Control	4	80	20	4
CCPR-2323B	Practical-IV	12	100	--	4
Total Credits of Sem-IV					**24**

Semester III:

CC-2312A: ASYMPTOTIC INFERENCE

Course Objectives: At the end of the course students will be able to:

CO1: Distinguish between weak and strong consistency, joint and marginal consistency

CO2: Understand the concept of CAN and BAN estimators, their related results.

CO3: Understand the concept of super-efficient estimator, variance stabilizing transformation and their application in large sample test.

CO4: Obtain the asymptotic confidence interval based on CAN and VST.

Unit and Credit	**CC-2312A: ASYMPTOTIC INFERENCE**	**No. of hoursper unit / credits**
Unit I	Consistency of an estimator, weak and strong consistency, joint and marginal consistency, invariance property under continuous transformations, methods of constructing consistent estimators, asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators	15
Unit II	CAN and BAN estimators in one parameter and multi-parameter exponential family of distributions, BAN estimators, super-efficient estimators, Crammer regularity conditions, Cramer – Huzurbazar results.	15
Unit III	Variance stabilizing transformations; their existence; their applications in obtaining large sample tests and estimators. Asymptotic Confidence Intervals based on CAN estimators and based on VST, Asymptotic Confidence regions in multi-parameter families.	15
Unit IV	Likelihood ratio test and its asymptotic distribution, Wald test, Rao's Score test, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. Consistent test, comparison of tests: asymptotic relative efficiency of tests (Pitman and Bahadur efficiency). Performance evaluation (based on simulation) of asymptotic tests and confidence intervals.	15

Books Recommended:

1. Kale B.K. (1999): A first course on parametric inference, Narosa Pub.
2. Zacks S. (1971): Theory of statistical inference, Wiley & Sons inc.
3. Rohatagi V.K. and Saleh A. K. Md. E.(2001) : Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.
4. Ferguson, T.S. (1996): A Course in Large Sample Theory. Chapman and Hall
5. Lehmann E L (1999): Elements of Large Sample Theory, Springer.
6. DasGupta A. (2008): Asymptotic Theory of Statistics and Probability, Springer Texts in Statistics.

CC-2313A: MULTIVARIATE ANALYSIS

Course Objectives: At the end of the course students will be able to:

CO1: Understand multivariate normal distribution and their real life applications.

CO2: Understand Wishart distribution, Hotelling T2 and Mahalanobis D2 statistic.

CO3: Implement dimension reduction techniques using software on real life problems.

CO4: Demonstrate knowledge of the basic ideas behind discriminant and clustering analysis techniques with applications.

Unit and Credit	CC-2313A: MULTIVARIATE ANALYSIS	No. of hoursper unit / credits
Unit I	Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, correlation matrix, graphical representation, means, variances, covariances, Partial and multiple correlation coefficients. Correlations of linear transforms. Multivariate normal distribution, two definitions and their equivalence, singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions.	15
Unit II	Maximum likelihood estimators of the parameters of the multivariate normal distribution and their sampling distributions. Hotelling's T2 Statistic and its null distribution. Applications of T 2 statistics and its relationship with Mahalanobis' D2 statistic. Confidence region for the mean vector, Wishart matrix and its distribution, properties of Wishart distribution, distribution of generalized variance.	15
Unit III	Discrimination and classification. Fisher's discriminant function and likelihood ratio procedure, minimum ECM rule, Rao's U statistics and its use in tests associated with discriminant function, classification with three populations. Cluster analysis, Hierarchical methods: Single, Complete, average linkage method and non-hierarchical clustering method-k-means clustering.	15
Unit IV	Canonical correlation analysis, Introduction to principal component analysis and related results, Introduction to factor analysis and estimation.	15

Books Recommended:

1. Kshirsagar A. M.(1972) : Multivariate Analysis. Marcel-Dekker. Company Inc,1961.
2. Johnson, R.A. and Wichern . D.W (2002) : Applied multivariate Analysis. 5thAd.Prentice – Hall.
3. Anderson T. W. (1984) : An introduction to Multivariate statistical Analysis2nd Ed. John Wiely.
4. Morrison D.F. (1976) : Multivariate Statistical Methods McGraw-Hill.

CC-2314A: STOCHASTIC PROCESSES

Course Objectives: At the end of the course students will be able to:

CO1: Understand the stochastic processes, Markov chain and Transition probability matrix, various types of states and limiting distribution.

CO2: Learn random walk model, Gambler Ruin Problem and able to compute long run distribution of Markov chain.

CO3: Apply the Poisson process, Birth and Death process and various Queuing systems in real life

CO4: Learn branching process and able to make simulation of Markov Chain, Poisson process and branching process.

Unit and Credit	CC-2314A: STOCHASTIC PROCESSES	No. of hours per unit / credits
Unit I	Definition of stochastic process, classification of stochastic processes according to state space and time domain, finite dimensional distributions. Examples of various stochastic processes. Definition of Markov chain. Examples of Markov chains, Formulation of Markov chain models, initial distribution, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities. Simulation of Markov Chain.	15
Unit II	Classification of states, irreducible Markov chain, period of the state, random walk and gambler's ruin problem, first entrance theorem, first passage time distribution. Long-Run proportions and limiting probabilities, relation with mean recurrence time, stationary distribution.	15
Unit III	Discrete state space continuous time Markov chain, Poisson process and related results. Birth and death processes and associated cases. Renewal and delayed renewal processes, related theorems, key renewal theorem (Without proof) and its application. Simulation of Poisson process and discrete state space Markov processes.	15
Unit IV	Galton-Watson Binaymi Branching process. Generating functions and its properties, moments. Probability of ultimate extinction. Distribution of population size and association results. Simulation of branching process. Basic elements of Queuing model. Steady state probabilities and various average characteristics for the models: M/M/1, M/M/1 with balking, M/M/c and M/G/1.	15

Books Recommended:

1. Bhat B. R. (2000). Stochastic Models: Analysis and Applications, (New Age International)
2. Cinlar E. (2013): Introduction to Stochastic Process. (Courier Corporation)
3. Feller W.(2008): An Introduction to Probability Theory and Its Applications. (Wiley)
4. Hoel P. G., Port S. C. and Stone C. J. (1987): Introduction to Stochastic Processes. (Waveland Press)
5. Karlin S. and Taylor H. M. (1968): A First Course in Stochastic Process. (Academic Press)
6. Medhi J. (2009): Stochastic Process, (New Age International Publications)
7. Ross S. (1996): Stochastic Processes. (Wiley)

8. Ross S. (2014): Introduction to Probability Models. (Academic Press)
9. Taylor H. M. and Karlin S. (2014): An Introduction to Stochastic Modeling (Academic Press)

CC-2315A: Data Mining

Course Objectives: At the end of the course students will be able to:
CO1: Understand and clean the big data sets.

CO2: Apply classification methods to real life problems in various fields.

CO3: Select and evaluate the models based on datasets using different modelling techniques.
CO4: Understand unsupervised learning and supervised learning techniques for univariate and multivariate data.

Unit and Credit	CC-2315A: Data Mining	No. of hoursper unit / credits
Unit I	Data understanding and data cleaning, concept of supervised and unsupervised learning. Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, classification based on logistic regression, Bayesian belief Network.	15
Unit II	Model evaluation and selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves. Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data.	15
Unit III	ANN and SVM: Artificial Neutral Network (ANN): Introduction to ANN, types of activation function, McCulloch-Pitts AN model, single layer network, multilayer feed forward network model, training methods, ANN & regression models. Support vector machine: Introduction to support vector machine, loss functions, soft margin, optimization hyperplane, support vector classification, support vector regression, linear programming support vector machine for classification and regression.	15
Unit IV	Unsupervised learning: Clustering: k-mediods, CLARA, DENCLUE, DBSCAN, Probabilistic model based clustering. Market Basket Analysis: Association rules and prediction, Apriori Algorithm, data attributes, applications to electronic commerce.	15

Books Recommended:

1. Berson and Smith S.J. (1997) : Data warehousing, Data Mining, and OLAP, McGraw-Hill.
2. Breiman J.H Friedman, R.A. Olshen and stone C.J. (1984) : Classification and Regression Trees, Wadsworth and Brooks / Cole.
3. Han, J. and Kamber, M. and Pei, J. (2012) : Data Mining: Concepts and Techniques.

MorganGaufmann.3rd Edition.
4. Mitchell T.M. (1997) : Machine Learning , McGraw-Hill.
5. Ripley B.D. (1996) : Pattern Recognition and Neural Networks. Cambridge University Press.
6. Vapnik V.N. The nature of Statistical learning theory, Springer.
7. Cristianini N. and Shawe-Taylor J. An Introduction to support vectormachines.
8. Data set source: http://www.ICS.uci.edu/~mlearn/MLRepository.html
9. Mehrika, K., Mohan, C., and Ranka (1997) Elements of Artificial neural networks. Penram international.
10. Hastie T, Tibshirani R, Friedmant J, (2009): The elements of statistical Learning, Springer.
11. Chattamvelli, R. (2015). Data mining methods. Alpha Science International.

CC-2316A: Time Series Analysis

Course Objectives: At the end of the course students will be able to:

CO1: Remove trend and seasonality using different methods to convert the time series into stationary.

CO2: Understand time series, auto-covariance, auto-correlation their properties, various smoothing techniques.

CO3: Obtain Causality and inevitability, π -weights and ψ- weights, ACVF, ACF, PACF.

CO4: Understand estimation of ARIMA model, residual analysis and diagnostic checking, their forecasting.

Unit and Credit	CC-2316A: Time Series Analysis	No. of hoursper unit / credits
Unit I	(a) Exploratory time series analysis, Exponential, Double exponential and Holt – Winter smoothing and forecasting. (b) Auto - Covariance, Auto-correlation functions and their properties and characterization (without proof), Partial auto covariance function, Auto – Covariance generating function. First and second order Stationary time series, white noise process, Linear Process, Sample Estimates of mean, Auto - Covariance, Auto-correlation and Partial auto covariance functions.	15
Unit II	Wold representation of linear stationary processes, linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average models. Causality and invertibility of ARMA processes, computation of π -weights and ψ- weights, computation of ACVF, ACF and PACF for AR(1), AR(2), MA(1), MA(2), ARMA(1,1) process and general procedure for ARMA(p,q) process. The need for differencing a time series, Autoregressive Integrated Moving Average models.	15
Unit III	(a) Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Residual analysis and diagnostic checking. Minimum mean squared error forecasting for ARMA and ARIMA models, updating forecasts. Introduction to SARIMA models. (b) Spectral	15

	Representation of the ACVF, Spectral density of an ARMA process, its computation for simple models.	
Unit IV	(a) Introduction to ARCH and GARCH models. Properties and estimation under ARCH(1) and GARCH(1,1) model. (b) Vector time-series models: Covariance and Correlation Matrix functions, MA and AR representation of vector processes, Covariance matrix function of the vector AR(1) and MA(1) models.	15

Books Recommended:

1. W. S. Wei (2005) Time Series Analysis: Univariate and Multivariate Methods
2. Box, G.E.P and Jenkins G.M. (1970) Time Series Analysis, Forecasting & Control, Holden-Day.
3. Brockwell, P.J and Davis R.A. (1987) Time Series: Theory and Methods, Springer-
4. TsayR. S. Analysis of Financial Time Series, 3rd Ed. (Wil. Ser. in Prob. and Statistics)
5. Kendall, M.G. (1978) Time Series, CharlerGraffin
6. Chatfield, C. (2004) The Analysis of Time Series - An Introduction, Sixth edition, Chapman and Hall.

CCPR-2317A: PRACTICAL -III

Practical Number	Practical Name
1	Construction of Consistent/CAN Estimators
2	Construction of BAN Estimators and confidence interval based on it.
3	Confidence interval based on CAN.
4	Confidence interval based on VST.
5	Exploratory data analysis
6	Application of Hotelling's T2 statistics
7	Discriminant Analysis
8	Principle component analysis and Factor Analysis.
9	Classification.
10	Cluster Analysis.
11	Artificial Neural Network.
12	Support Vector Machine.
13	Simulation of Markov chain
14	Classification of t.p.m. and computation of n- step probability matrix.
15	Classification of states: Computations of absorption probabilities.
16	Stationary distribution and recurrence time.
17	Auto covariance and Autocorrelation.
18	Causal and Invertible
19	Smoothing the series
20	Forecasting

(Each practical should consist of problems to be solved using at least two of the following software: EXCEL/ R/python)

Semester IV:

CC-2318B: Generalized Linear Models

Course Objectives: At the end of the course students will be able to:

CO1: Understand and use the principles of statistical modelling.

CO2: Understand the general theory of GLM and apply GLM for the analysis related to data sets in various domains

CO3: Understand concept of Logistic regression and Poisson regression and its implementation in real life situation.

CO4: Understand concept of Generalized linear mixed models.

Unit and Credit	**CC-2318B: Generalized Linear Models**	**No. of hoursper unit / credits**
Unit I	Generalized linear models: concept of generalized linear model, Link function, ML estimation, Quasi-likelihood estimation, large sample tests about parameters, goodness of fit, analysis of deviance. Residual analysis, types of residuals: raw, Pearson, deviance, Anscombe, quantile; residual plots. Variable selection: AIC and BIC.	15
Unit II	Logistic regression: logit, probit and cloglog model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters. Hosmer-Lemeshow test, ROC curve. Multilevel logistic regression, Logistic regression for Nominal response: Baseline Category model and ordinal response: Proportional odds model.	15
Unit III	Poisson regression: ML and Quasi-likelihood estimation of parameters, testing significance of coefficients, goodness of fit, power family of link functions, over dispersion: Types, causes and remedies. Negative Binomial regression: NB-2 model.	15
Unit IV	Generalized linear mixed models (GLMM): Structure of the model, consequences of having random effects, estimation by maximum likelihood, marginal versus conditional models, estimation by generalized estimating equations and conditional likelihood, tests of hypothesis: LRT, asymptotic variance, Wald and score test.	15

Books Recommended:

1. Hosmer D.W. and Lemeshow S. (2000): Applied Logistic regression, 2nd ED. Wiley New York.
2. Agresti A. (1990) : Categorical Data Analysis. Wiley , New York.
3. R. Christensen (1997) Log-Linear Models and Logistic Regression, Springer. New York.
4. Hilbe, J. (2011): Negative Binomial regression, Cambridge University, Press, 2nd Edition.
5. McCulloch, C. E., & Searle, S. R. (2003). Generalized, linear, and mixed models, Wiley series in probability and statistics, New York. andMathematical Statistics -3rd Edition, John Wiley & sons.

CC-2319B: Survival Analysis

Course Objectives: At the end of the course students will be able to:
CO1: Collect the life time data using different methods of censoring.

CO2: Apply the Cox regression model.

CO3: Understand concept of competing risk analysis and how to apply in real life situations.
CO4: Use regression methods for life time data.

Unit and Credit	**CC-2319B: Survival Analysis**	**No. of hours per unit / credits**
Unit I	**Estimating the survivor function:** Various types of censoring: right, left, interval Censoring; random censoring; Survivor, hazard and cumulative hazard functions. Estimating the survivor function: Life-table estimate, Kaplan-Meier estimate, Nelson-Aalen estimate; Standard error of the estimated survivor functions; Confidence intervals for values of the survivor function; Estimating the hazard function; Estimating the cumulative hazard function; Estimating the median and percentiles of survival times; Confidence intervals for the median and percentiles.	15
Unit II	**The Cox regression model:** A regression model for the comparison of two groups; The general proportional hazards model, Models corresponding to the linear component of the model: including a variate, a factor, an interaction, a mixed term. Fitting the Cox regression model in R, Likelihood function for the model, Treatment of ties, Confidence intervals and hypothesis tests for coefficients and for hazard ratios using R; Measures of explained variation, Measures of predictive ability, Model checking using various types of residuals: Cox-Snell; Modified Cox-Snell; Martingale; Deviance; Schoenfeld; Score residuals, plots based on these residuals and their interpretation.	15
Unit III	**Competing risks:** Summarizing competing risks data; Kaplan-Meier estimate of survivor function; its properties without proof, Hazard and cumulative incidence functions; Causespecific hazard function; Cause-specific cumulative incidence function; Likelihood functions for competing risks models; Parametric models for cumulative incidence functions.	15
Unit IV	**a) Comparison of two groups of survival data:** The log-rank test; The Wilcoxon test; Comparison of three or more groups of survival data. **b) Introduction to frailty Models:** Random effects, Individual frailty, Shared frailty; Frailty distributions: The gamma frailty distribution; Lognormal frailty effects; Testing for the presence of frailty; The shared frailty model; Fitting the shared frailty model; Comparing shared frailty models.	15

Books Recommended:

1. Collet, D. (2015). Modeling Survival Data in Medical Research. London: Chapman and Hall.
2. Hosmer, D. and Lemeshow S. (1999). Applied Survival Analysis: Regression Modeling of Time toEvent Data. New York: Wiley.
3. Breslow, N. and Day, N. (1987). Statistical Methods in Cancer Research, v. 2: The Design and
4. Analysis of Cohort Studies. Lyon: IARC.
5. Therneau T, and Grambsch, P. (2000). Modeling Survival Data: Extending the Cox Model. New
6. York: Springer.
7. Kalbfleish, JD. and Prentice, RL. (2002). The Statistical Analysis of Failure Time Data. New York:Wiley.

CC-2320B: Biostatistics

Course Objectives: At the end of the course students will be able to:

CO1: Understand need and ethics of any clinical trial and how to conduct clinical trial of any medicine in different phases.

CO2: Apply various designs of clinical trials to the data.

CO3: Understand the designs of clinical trials and Epidemiological studies.

CO4: Analyze and report the clinical trials.

Unit and Credit	CC-2320B: Biostatistics	No. of hours per unit / credits
Unit I	Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, Multi-center trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice, concept of blinding/masking in clinical trials. Bioavailability, pharmacokinetics and pharmaco-dynamics, two compartment model.	15
Unit II	Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping.	15
Unit III	: Design of bio-equivalence trials, Inference for 2x2 crossover design: Classical methods of interval hypothesis testing for bioequivalence, Bayesian methods, nonparametric methods. Reporting and analysis: analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials.	15
Unit IV	Epidemiological studies: case-control and cohort designs. Measures of disease occurrence and association, variation and bias, Identifying non-causal association and confounding, communicating results of epidemiological studies, ethical issues in epidemiology. Causal Inference.	15

Books Recommended:

1. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
2. Chow S.C. and Liu J.P. (2004). Design and Analysis of Clinical Trials. 2nd Ed. Marcel Dekkar.
3. Chow S.C. and Liu J.P.(2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Ed. CRC Press.
4. Clayton, D. and Hills, M. (2013). Statistical methods in Epidemiology, OUP.
5. Daniel, W. W. and Cross, C. L. (2012). Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition, Wiley.
6. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments.Wiley and Sons.
7. L. M. Friedman, C. Furburg, D. L. Demets (1998). Fundamentals of Clinical Trials, Springer Verlag.
8. Marubeni .E. and Valsecchi M. G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley.
9. S. Piantadosi (1997). Clinical Trials: A Methodologic Perspective, Wiley and Sons.

CC-2321B: Optimization Techniques

Course Objectives: At the end of the course students will be able to:

CO1: Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.

CO2: Apply simplex method to solve real life problems.

CO3: Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis.

CO4: Understand the concept of Game theory and dynamic programming to solve their problems and understand their real life applications

Unit and Credit	**CC-2321B: Optimization Techniques**	**No. of hoursper unit / credits**
Unit I	Convex Sets and Functions: Convex sets, supporting and separating hyperplanes, convex polyhedra and polytope, extreme points, convex functions. Linear programming problem (LPP): Definition and applications, methods of solving LPP: Graphical method, Simplex method, theorems related to the development of simplex algorithm, theorems related to a basic feasible solution, reduction of a feasible solution to a basic feasible solution, improvement of a basic feasible solution, existence of unbounded solution, optimality conditions and other related theorems (statements only), Examples. Artificial variable technique: Two phase method, Big M method, degeneracy.	15

Unit II	Concept of Duality, related theorems, complementary slackness property and development of dual simplex algorithm. Sensitivity Analysis: Changes in the cost vector, requirement vector and non-basic activity vector; addition of new variables and addition of new constraints.	15
Unit III	Integer Linear Programming Problem (ILPP): The concept of cutting plane, cutting plane method for all ILPP and mixed ILLP, Branch and Bound method. Quadratic programming: KuhnTucker conditions, methods due to Beale,	15
Unit IV	Theory of games: two person zero sum games, minimax and maximin principles, Saddle point, mixed strategies; rules of dominance, solution of 2 x 2 game by algebraic method, Graphical method, Reduction of the game problem as LPP. Dynamic Programming: The Recursion Equation Approach, Computational Procedure, Characteristics of Dynamic Programming, Solution of L.P.P. by Dynamic Programming.	15

Books Recommended:

1. Hadley G.(1969): Linear Programming, Addison Wesley
2. Taha H. A. (1971): Operation Research: An Introduction, Macmillan N.Y.
3. KantiSwaroop& Gupta M. M.(1985): Operations Research, Sultan Chand & Co. ltd.
4. P.Gupta&D.S.Hira(2010): Operation Research, Sultan Chand & Co. ltd.
5. J. K. Sharma. (2003): Operation Research: Theory and Applications. Macmillan.

CC-2322B: Statistical Quality Control

Course Objectives: At the end of the course students will be able to:
CO1: Understand concepts of control charts in quality improvement.
CO2: Construct modified control charts to monitor the process.
CO3: Analyze process capability using control charts.
CO4: Evaluate the quality of products using various acceptance sampling plans.

Unit and Credit	**CC-2322B: Statistical Quality Control**	**No. of hoursper unit / credits**
Unit I	Quality Improvement Tools: affinity diagram, interrelationship digraph, tree diagram, prioritization matrix, matrix diagram, process decision program chart, activity network diagram, stem-and-leaf display, dot diagrams, boxplot, and normal probability plot, Engineering Process Control. Shewhart Control charts: basic statistical principles and assumptions, phase I and phase II applications, benefits from the use of control charts, concept of rational subgroups, performance measures of a control chart, X, R, S, S2 , p, c and D charts, σ-control limits and probability control limits, over dispersion. Modifications to control chart procedures:	15

	warning limits, sensitizing rules, adaptive design parameters, integration of two charts. Concept of economic design of a control chart.	
Unit II	Alternatives to Shewhart control charts: CUSUM and EWMA charts, Shewhart–EWMA Chart. Multivariate Control Charts: multivariate chart versus individual charts, Hotelling's T2 control chart, multivariate CUSUM Charts, multivariate EWMA charts, Regression adjustment. Other Control Charts: SPRT chart, GLR Chart, charts for autocorrelated data, nonparametric control charts, Bayesian control charts. The change point model for process monitoring.	15
Unit III	Process capability Analysis: process capability, process capability indices (Cp, Cpk, Cpm, Cpmk), point and interval estimation of Cp and Cpk, Nonparametric Capability Indices: robust capability indices, capability indices based on fitted distributions, data transformation, capability indices computed using resampling methods. Multivariate Process Capability Indices. Six Sigma Methodology: components of a Six Sigma methodology, the DIMAC process, Six Sigma applications, Six Sigma concept for customer satisfaction, Six Sigma training, Lean Six Sigma.	15
Unit IV	Acceptance sampling plans for attributes: single sampling plan, double and multiple sampling plans, sequential sampling. Performance measures of sampling plans. Acceptance sampling plans for variables: Advantages and Disadvantages of Variables Sampling, Sampling inspection plans by variables for one or two sided specifications, Sequential Sampling by Variables, Rectifying inspection of lots, the Deming inspection criterion, Continuous sampling plans, skip-lot sampling plans.	15

Books Recommended:

1. Guenther, W. C. (1977). Sampling Inspection in statistical quality control. Macmillan.
2. Kenett, R. S. and Zacks, S. (2014). Modern Industrial Statistics with applications in R, MINITAB and JMP. John Wiley & Sons.
3. Montgomery, D. C. (2010). Statistical Quality Control: A Modern Introduction, 6th Edition. Wiley India Pvt Ltd.
4. Ryan, T. P. (2011). Statistical Methods for Quality Improvement. John Wiley & Sons.

CCPR-2323B: PRACTICAL -IV

Course Objective: Students should to understand and implement theory in real life problems.

Practical Number	Practical Name
1	Generalized Linear Models Practical I
2	Generalized Linear Models Practical II
3	Nonparametric Estimation of Survival and Related Functions
4	Cox-Regression Model
5	Pharmokinetics.
6	Confidence interval.
7	Analysis of categorical outcomes.
8	Non-parametric test based on Clinical Trials.
9	Formulation, Solution Using Graphical and Simplex Method of LPP
10	Application of Two Phase and Big-M Method
11	Duality and Application of Dual Simplex Method
12	Integer Programming and Quadratic Programming Problem
13	Game Theory
14	Control Charts for Variables
15	Control Charts for Attributes

(Each practical should consist of problems to be solved using at least two of the following software: EXCEL/ R/python)

Nature of Theory Question Paper:

Time: 3 hours **Total Marks: (80)**

Instructions: (1) All the questions are compulsory.
(2) Figures to the **right** indicate **full** marks.
(3) (Paper setter may add or delete any instruction if required)

Question Number	**Pattern of Question**	**Marks**
Q.1	Select correct Alternative (8 questions carrying 1 mark each)	1 X 8 =8
Q.2	Attempt any three i) ii) iii) iv) v)	16 X 3 =48
Q.3	Attempt any four i) ii) ii) iv) v) vi)	6 X 4 =24
	Total	**80**

Nature of Practical Question Paper:

a) For Semester I and II, "Practical CCPR-2305, CCPR-2311,

1) There shall be 20 marks for day-to-day performance and journal.
2.) Examination (60): Practical Examinations will be conducted at the end of the term. Practical exam will be of 3 hrs. duration carrying 60 marks. There shall be 8 questions each of 12 marks, of which a student has to attempt any 5 questions.
3) Practical VIVA will be for 20 marks.

b) For Semester III and IV: Practical CCPR-2319, CCPR-2327

1. There shall be 10 marks for day-to-day performance and journal.
2. Examination (50): Practical Examinations will be conducted at the end of the term. Practical exam will be of 3 hrs. duration carrying 50 marks. There shall be 7 questions each of 10 marks, of which a student has attempt any 5 questions.
3. Practical VIVA will be for 10 marks.

4. Project work carries 60 marks.

Semester		Marks	Total Marks
III	Search & Define Problem	10	30
	Data Collection, Variable Understanding	10	
	Exploratory Data Analysis	10	
IV	Data Analysis	10	30
	Project Report	10	
	PPT and VIVA	10	

Note: The Master in Statistics Practical (MSP) examination shall be conducted semester wise with individual heads of passing with minimum 40% marks.

Nature of Internal Assessment:
There shall be Continuous Internal Evaluation pattern as follows:

1	**Attendance**	**5 Marks**
2	**Seminar**	**15 Marks**
3	**Internal exam**	**20 Marks**

Conversion of 40 marks into 20 marks.

VIVEKANAND COLLEGE KOLHAPUR (Empowered Autonomous) ESTD JUNE 1964

HEAD
DEPARTMENT OF STATISTICS
VIVEKANAND COLLEGE, KOLHAPUR
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