RAYALASEEMA UNIVERSITY: KURNOOL

Dept. of OR & SQC

Minutes of meeting of Board of studies in MSc., OR&SQC held on 27.08.2022 at 10.30 am in the Vice Chancellor's Conference Hall , Administrative building, Rayalaseema University, Kurnool.

Members:

DR. K. SREENIVASA RAO Professor & Head, Dept. of OR&SQC	**Chairman**
DR. GVSR ANJANEYULU Professor, Dept. of Statistics, ANU, Guntur	External Member
DR. B. MUNI SWAMY Professor, Dept. of Statistics, Andhra University, Vizag	External Member
DR. UJJAL KUMAR BEHRA Supdt. Engineer, The Singareni Collieries Co. Ltd.,Kottagudem, Khammam	External Member
PROF.K.PUSHPANJALI Professor, Dept. of Statistics SK University, Anantapur	Special Invitee
DR. S. MADHUSUDANA VERMA Professor, Dept. of OR&SQC	Member

ITEM: **Modification of Syllabus**

RESOLUTIONS:

The syllabus has been thoroughly examined and it is unanimously resolved:

- There shall be two core theory papers in each semester, Compulsory Foundation/ Internal Elective / Open Elective/Generic Elective-Choose one paper- with practical examinations scheduled at the end of the each semester w.e.f academic year 2022-23.

- There shall be end 1ST Year(I&II-Semesters) and 2nd Year(III&IV-Semesters) Comprehensive viva(Evaluated by Senior Professor)
- In the third semester there will be SPSS Lab practical
- In the fourth semester, there will be project work which is evaluated by external examiner at the end of the semester.
- The pattern of theory examinations is as totals.
  - ✓ Semester-end Examination : 80 Marks
    - Section A: 20 Marks
      (Five short answer questions, with internal choice within the units)
    - Section B: 60 Marks
      (Five essay answer questions, with internal choice within the units)
  - ✓ Internal Examination : 20 Marks

- For I, II ,III and IV semesters practical examination, the division of marks is as follows:
  - ✓ 75 marks for Practical questions (25 marks x 3 Questions)
  - ✓ 25 marks for record
  - ✓

The revised course structure and syllabus is enclosed in Annexure – I, and is to be followed from the academic year 2022-23. It is also resolved to follow the list of subject experts as in Annexure-II.

Signatures:

DR. K. SREENIVASA RAO :

DR. GVSR ANJANEYULU :

DR. B. MUNI SWAMY :

DR. UJJAL KUMAR BEHRA :

PROF.K.PUSHPANJALI : 27/08/2022

DR. S. MADHUSUDANA VERMA :

Paper OR22101: PROBABILITY AND DISTRIBUTION THEORY

UNIT-I

Concept of Field – Sigma Field – Set function and Measure – Probability as a measure – Concept of MGF, CF and their properties – Uniqueness Theorem (Statement only) – Markov, Tchebycheff Holder and Jensen Inequalities – Weak and Strong Law of Large Numbers.

UNIT-II

Convergence in Probability almost sure – Means Square convergence and its distribution – CLT For Sequence of Independent (Random Variable), CLT For IIDs – Lindeberg – Levy, Liapnov's Form.

UNIT-III

Standard Distributions – Hyper Geometric, Multinomial, Weibull, Lognormal, Gamma and Beta Distributions (Concept and Applications without Derivations).

UNIT-IV

Multiple Linear Regression – Multiple Correlation – Partial Correlation and it's application.

UNIT-V

Sampling Distribution – Mean, Variance, t, F, χ^2 Distributions with their properties,MGF,CF,Linking diatribution and their application.

References

- Robert B. Ash, **Real Analysis and Probability**, Academic Press (1972).
- Billingsley P., Probability and Measure, Wiley (1986).
- B.R. Bhat, **Modern Probability Theory**, New Academic Science; 4th Edition (2018).
- Rohatgi V.K., **An Introduction to Probability Theory and Mathematical Statistics**, Wiley-Blackwell (1976).
- A. M. Gun, M. K. Gupta, B. Dasgupta , **An Outline of Statistical Theory: Volume 1**, The World Press Private Ltd (2013).
- R. M. Dudley, **Real Analysis and Probability** (Wadsworth and Brooks/Cole Mathematics Series, Pacific Grove, California, 1989).
- Kingman, JFC and Taylor S.J., **Introduction to Measure and Probability**, Cambridge U.P., London (1966).
- Dudewicz E.J. and Mishra S.N., **Modern Mathematical Statistics**, John Wiley & Sons (1988).

Paper OR22102: MATHEMATICAL PROGRAMMING-I

UNIT-I

Introduction - Definition and Scope of Operations Research (OR) – Different types of models and general methods of solution – Different types of Allocation Models – Concept of Optimal Solution.

UNIT-II

General LPP, Properties of the solution to LPP, generating extreme point solution, Graphical Method and some special cases. Simplex method – Duality – Dual Simplex method – Sensitivity Analysis.

UNIT-III

Revised Simplex procedure – problem of Degeneracy - Applications and examples – Transportation problem – Initial Basic Feasible Solution & Optimal solution (u,v) method – Assignment Problem – Solution by Hungarian.

UNIT–IV

Concept of Integer Programming Problem – Gomory's Cutting Plane algorithm for all integer & mixed Integer Programming Problems. Branch & Bound Method and applications of Zero-one Integer Programming.

References

- Man Mohan, P. K. Gupta, Kanti Swarup, **Introduction to Management Science Operations Research** , Sultan Chand & Sons (2014)
- Hadley, H.Addision, **Linear Programming** – Addison-Wesley Publishing Company, Reading, Mass. (1962)
- Murthy, K.G: **Linear Programming**; John Wiley & Sons; 1 edition (1983)
- Hiller, F.S., and Lieberman, **Introduction to Operations Research**, McGraw Hill Education India; 10 edition (2017)
- Willard I. Zangwill., **Nonlinear programming : A Unified Approach**, Prentice-Hall, [1969]
- Fletcher R., **Practical Methods of Optimization,** Wiley; 2nd Edition (2000)
- Hamdy A Taha, **Operations Research** : An Introduction 10th Edition, PEARSON Publications (2017).

Compulsory Foundation

Paper OR22103 [A]: DATA ANALYSIS USING SPSS, EXCEL & NUMERICAL METHODS

UNIT-I :

Basics of SPSS – Editing, Printing – Creating And Editing Of Files – Managing Data, Listing Cases, Replacing Values, Computing New Variables, Rewriting Variables, Exploring Data, Selecting Cases, Sorting Cases, Merging Files.

UNIT-II :

SPSS Data Analysis: Graphs – creating and editing of graphs and charts – Bar Diagrams, Histograms, Percentiles, Statistical Application, Descriptive Statistics, Bi-Variate Correlation, Linear Models, Multiple Regression.

UNIT-III:

Excel work sheet – Creating data files in Excel – Formatting cells, sorting – Graphs and charts – Curve fitting and Interpretation of the output – Statistical functions in Excel – Calculation of Theoretical probabilities using Binomial, Poisson and Normal Distributions – Mathematical Functions – Matrix Operation-Transpose product and Inverse Operations using Excel

UNIT-IV:

Numerical Analysis and Statistical Applications – Programming skill in numerical methods, Matrix computations – Solving of equations using Newton-Raphson method - Solving Simultaneous Equations using Gauss Elimination and Gauss Siedel method. Numerical Integration – Simpson's 1/3 and 2/8 rules.

References

- Rajaraman V, **Computer-Oriented Numerical Methods**, PHI Learning Private Limited; 3rd Edition (2013).
- K.V.S. Sarma, **Statistics Made Simple Do it yourself on PC**, Prentice Hall India Learning Private Limited; 2 edition (2010).
- Anil Kumar Mishra, **A Hand Book on SPSS for Research Work**, Himalaya Publications, 2 edition (2019).

Compulsory Foundation

Paper OR22103 [B]: DATA ANALYSIS USING R

UNIT-I:

Familiarizing with R environment, Using R console as a calculator, R atomic types, methods of creating vectors, combining vectors and repeating vectors, different ways of subsetting vectors using indexing, names and logicals. Arithmetic and logical operations. Using character vectors for text data, manipulating text using strsplit(), paste(), cat(), grep(), gsub() functions; handling factor data. Working with dates.

UNIT – II:

Creating Matrices, getting values in and out of matrices, performing matrix calculations; Working with multidimensional Arrays; creating data frames, getting values in and out of data frames, adding rows to data frame, adding variables to data frame; creating lists, extracting components from a list, changing values of components of lists. Getting data into and out of R - reading data in CSV files, EXCEL files, SPSS files and working with other data types. Getting data out of R – working with write.csv() and write.table() functions.

UNIT – III:

Writing Scripts and functions in R. writing functions with named, default and optional arguments. functions using as arguments. Debugging your code. Control statements in R – conditional control using if, if-else, ifelse; looping control using for, while, repeat; transfer of control using break and next. Manipulating and processing data - creating subsets of data, use of merge() function, sorting and ordering of data. Group manipulation using apply family of functions - apply, sapply, lapply, tapply.

UNIT – IV:

Working with probability distributions - normal, binomial, Poisson and other distributions. Summary statistics, hypothesis testing - one and two-sample Student's t-tests, Wilcoxon U-test, paired t-test, paired U-test, correlation and covariance, correlation tests, tests for association- Chi-squared test and goodness-of- fit tests. Formula notation, one-way and two-way ANOVA and post-hoc testing, graphical summary of ANOVA and post-hoc testing, extracting means and summary statistics; linear regression.

References:

1. Mark Gardener(2012), Beginning R - The Statistical Programming Language, Wiley India Pvt Ltd.
2. Andrie de Vries and JorisMeys(2015), R Programming for Dummies, Wiley India Pvt Ltd.
3. Jared P. Lander(2014), R For Everyone - Advanced Analytics and Graphics, Pearson Education Inc.

Internal Elective

Paper OR22104(A): LINEAR MODELS & APPLIED REGRESSION ANALYSIS

UNIT-I:

Two and Three variable Linear Regression models; General linear model: Assumptions; OLS estimation; BLUE; Tests of significance of individual regression coefficients; Testing the equality between two regressions coefficients; Test of significance of complete regression.

UNIT-II:

Criteria for model selection; Goodness of fit measures; R2 and adjusted R2 Criteria; Cp criterion; testing the general linear hypothesis; Chow test for Equality between sets of regression coefficients in two linear models; test for structural change; restricted least squares estimation; Generalized Mean Squared error criterion.

UNIT-III:

Non-normal disturbances and their consequences; test for normality; Jarque-Bera test; Shapiro-Wilk test, Minimum Absolute Deviation (MAD) estimation; Box-Cox transformations.

Statistical analysis of residuals, OLS residuals, BLUS residual, Studentised residual, Predicted residual, tests against heteroscadasticity.

UNIT-IV:

Non-Linear regression; Non linear least squares estimation; Maximum Likehoodestimation; Idea of computational methods; Gradient methods, Steepest descent method and Newton-raphson method; testing general Nonlinear hypothesis; Wald test, Lagrange multiplier test and likelihood ratio Test. Robust , probit, binomial logistic ,multiple logistic regression.

References

1. Johnston, J (1984): Econometric Methods, III rd edition. MC Graw Hill.
2. Gujarathi, D (1979): Basic Econometrics, MC Graw Hill.
3. Judge, C.G., Griffiths, R.C.Hill, W.E ., Lutkephol, H and Lee, T.C (1985): The Theory and Practice of Econometrics, John Wiley and Sons.
4. Draper, N and Smith, B (1981): Applied Regression Analysis, Second Edition

Internal Elective

Paper OR22104(B): STATISTICAL INFERENCE-I

Unit-I

Point Estimation – concept of Unbiasedness – Consistency – Minimum Variance Unbiased Estimation – Information in a Sample – Cramer-Rao Inequality – Efficiency of an Estimator – Bhattacharya bounds – Definition of CAN Estimator.

UNIT-II

Concept of sufficiency – Single Parameter Case – Minimal sufficient statistics – Exponential families – Distribution admitting sufficient Statistics – Rao-Blackwell Theorem – Completeness.

UNIT-III

Methods of Estimation – Minimum Variance method – M.L. Method of Estimation – For Complete samples.

UNIT-IV

M.L. Estimation for Failure Censored and Time Censored Sample – Interval Estimation – Confidence Interval – Shortest Confidence Interval.

UNIT-V

Elements of Decision Theory – Loss and Risk Functions and Admissibility – Minimum Decision Rules – Randomized Decision Rules.

References

- Alan Stuart, J. Keith Ord, **Kendall's Advanced Theory of Statistics, Distribution Theory, Volume 2; Classical Inference and Relationship**, 5th Edition, Oxford University Press (1991).
- Alexander M. Mood, Franklin A. Graybill , Duane C. Boes, **Introduction to the Theory of Statistics**, McGraw Hill; 3rd edition (1973).
- V. K. Rohatgi, **An Introduction to Probability Theory and Mathematical Statistics**, Wiley; Edition 1 (1976)
- M. K. Gupta, A. M. Gun, B. Dasgupta , **An Outline of Statistical Theory: Volume 2**, World Press Private Ltd (2013).
- Wilks S.S., **Mathematical Statistics**, Nabu Press (2011)
- S. K.; Kale, B. K. Sinha, **Life Testing and Reliability Estimation**, Wiley Eastern Limited (1980).

Paper OR22201: MATHEMATICAL PROGRAMMING – II

UNIT – I

Non-Linear Programming (NLP) – NLPP with constrained and unconstrained optimization - Kuhn-Tucker necessary & sufficient condition Quadratic Programming (QP) and Wolfe's Modified Simplex Algorithm – Beale's Method of Solution to QP problem.

UNIT – II

Bellman's Principle of Optimality – Characteristics of Dynamic Programming Problem – Recursive relationship of Dynamic Programming for various Optimization problems of Shortest Path – Allocation problems – Cargo Loading – Production Scheduling – D.P. for Algebraic problems.

UNIT – III

Concept of Goal Programming (GP) – GP Model Formulation – Single Goal with multiple sub goals – Equally Ranked Multiple Goals – Ranking and Weighing of unequal Multiple Goals – General GP model – Graphical Solution method of GP – Modified Simplex method of GP.

UNIT – IV

Optimization using Spread Sheets - Stepwise procedure with examples – Solution to LPP, Transportation, Assignment problems using Excel Solver.

References

- Man Mohan, P. K. Gupta, Kanti Swarup, **Operations Research** , Sultan Chand & Sons (2014).
- Hiller, F.S., and Lieberman, **Introduction to Operations Research**, McGraw Hill Education India; 10 edition (2017).
- Katta G Murty, **Linear Complementarity Linear and Nonlinear Programming**, John Wiley & Sons (1983).
- Hamdy A Taha, **Operations Research** : An Introduction 10th Edition, PEARSON Publications (2017).
- Stuart E. Dreyfus, **The Art and Theory of Dynamic Programming**, Academic Press (1977).
- R. Fletcher, **Practical Methods of Optimization**, 2nd Edition, John Wiley (1987).
- Willard I. Zangwill., **Nonlinear programming : A Unified Approach**, Prentice-Hall, [1969].

Paper OR22202: STATISTICAL INFERENCE-II

UNIT-I

Testing of Hypothesis – Simple and Composite Hypotheses – Two types of Errors – Critical Region – Power Function, Most powerful tests – Neyman-Pearson lemma - Uniformly most powerful unbiased test.

UNIT-II

Concept of Similar Regions – Likelihood Ratio Test and it's asymptotic distribution – one sample, two sample and k sample problems.

UNIT-III

Wald's SPRT – Fundamental identity, Termination of SPRT in a finite number of steps with certainty, O.C. and ASN functions.

UNIT-IV

SPRT for different distributions-SPRT for Binomial Proportion – Normal mean and variance – Advantage of SPRT-Five points on OC and ASN curves.

UNIT-V

Non Parametric Tests: Sign, Median, Mann-Whitney and Run tests – Wilcoxon test for one and two samples – Kolmogorov-Smirnov test for one sample and two samples.

References

- E. L. Lehmann, **Testing Statistical Hypotheses**, John Wiley and Sons, Inc., New York, (1959).
- Alan Stuart, J. Keith Ord, **Kendall's Advanced Theory of Statistics, Distribution Theory, Volume 2; Classical Inference and Relationship**, 5th Edition, Oxford University Press (1991).
- Alexander M. Mood, Franklin A. Graybill , Duane C. Boes, **Introduction to the Theory of Statistics**, McGraw Hill; 3rd edition (1973).
- V. K. Rohatgi, **An Introduction to Probability Theory and Mathematical Statistics**, Wiley; Edition 1 (1976).
- M. K. Gupta, A. M. Gun, B. Dasgupta , **An Outline of Statistical Theory: Volume 2**, World Press Private Ltd (2013).
- Wilks S.S., **Mathematical Statistics**, Nabu Press (2011).
- Abraham Wald, **Sequential Analysis**, John Wiley and Sons, Inc. (1947).
- Sidney Siegel, **Nonparametric Statistic for the Behavioral Sciences**, McGraw Hill; Spine Lean/Underlining edition (1956).

Compulsory Foundation

Paper OR22203(A): INDUSTRIAL EXPERIMENTAL DESIGNS & SAMPLING

UNIT-I

Principle of Experimental design – Concepts of factorial Experiments – Construction of 2^n & 3^n Factorial Experiments. Treatment Combination in Standard Order for 2^n designs. The Table of Signs and Yate's Method.

UNIT-II

Concept of Confounding – Construction of Principle Block and Alternative Block using confounding interactions - Total and Partial Confounding in Factorial Experiments – Confounding Designs 2^n Design and Analysis.

Unit-III

Incomplete Block Designs - B.I.B.D, P.B.I.B.D. their analysis – Estimation of Parameters, tests of Hypothesis – Yuden Design – Inter block analysis – Factorial Designs – Analysis of Factorial Designs of 2^n Series Experiments.

Unit-IV

Response Surface – Analysis using Central Composite and Rotatable and Design and Path of Steepest Ascent Method - Concept of Evop.

UNIT-V

Sampling Techniques and Estimation – Simple random sampling with and without replacement – Stratified sampling – allocation problem – systematic sampling – Two stage sampling – Related estimation problems in the above cases.

References

- Douglas c and Montgomery, **Design and Analysis of Experiments**, 9th Edition John wiley & Sons, New York (2017).
- Cochran, W.G. and Cox, G.M., **Experimental Designs**, 2nd Edition, John Wiley and Sons, New York (1992).
- Chakrabarti M.C, **Mathematics of Design and Analysis of Experiments**, Asia Publishing House, UK (1962).
- Klaus Hinkelmann, Oscar Kempthorne, **Design and Analysis of Experiments**, Volume 1: Introduction to Experimental Design, 2nd Edition, John Wiley (2007).

Compulsory Foundation

Paper OR22203(B): TIME SERIES ANALYSIS AND FORECASTING METHODS

UNIT - I:

Review of Time Series Analysis. Growth models: Modified Exponential Curve, Gompertz curve, Logistic curve and their Fitting; Measurement of cyclical component: Harmonic analysis, auto regression series: Markoff and Yule's series, Periodogram and correlogram analysis, measurement of irregular component: variate difference method.

UNIT - II:

Need and uses of forecasting, classification and characteristics of forecasts, forecasting based on regression techniques: simple and multiple linear regression and nonlinear regression techniques, moving averages smoothing methods: simple and double, multi average methods; explanatory version time series forecasting, test for trend seasonality.

UNIT – III

Exponential smoothing methods: trend adjusted exponential smoothing, double and triple exponential smoothing, win ten's method, chow's adaptive control methods, brown's one parameter adaptive method: Box-Jenkins three parameter smoothing, Harrison's Harmonic smoothing methods, tracking signal.

UNIT – IV

Box-Jenkin's time series methods: 1. Moving average 2. Autoregressive (AR) 3. ARMA and 4. AR integrated MA (ARIMA) models.

UNIT-V

estimation of ARIMA model parameters, forecasting with ARIMA models, Diagnostic checking of the model: Analysis of residuals, forecasting using transfer function model, concept of Kalmon's Filters.

Reference

- Thomopouls, N.T (1980): Applied Forecasting Methods. Engle Wood Cliffs, N.J, Prentice Hall.
- Wheel Wishart, S.C; and S. Makridaks (1980): Forecasting Methods for Management . III edition, New York. John Wiley.
- Sullivan, William G. and Wayne Claycambe. W (1977): Fundamentals of Forecasting. Prentice Hall. Virginia.
- Gupta. S.C and V.K. Kapoor (1995): Fundamentals of Applied Statistics, Sulthan & Chand Sons. New Delhi

Internal Elective

Paper OR22204 (A): STATISTICAL QUALITY CONTROL – I

UNIT-I

Introduction: Brief history of Quality Control– causes of Variation – Statistical Basis for Control Charts - Principles of Shewart's control chart.

UNIT-II

Control Charts for variables – Introduction - $\bar{X}$ and R Chart: Statistical Basis of the charts - development and use of $\bar{X}$ and R Charts - OC Curve of $\bar{X}$ and R chart.

UNIT-III

Control charts for Attributes – Development and Operation of 'p' and 'np' charts with constant and variable sample size, C and U charts – Operating Characteristic curve.

UNIT-IV

Special Control Charts for variables: Notion of ARL – CUSUM chart – Comparison of CUSUM charts with Shewart's control charts, V mask and decision interval methods – Control chart for Mid Ranges – Moving Averages & Moving ranges – Groups control and modified control charts – Exponential Weighted Average (EWMA) charts.

References

- Montgomery, Douglas C., **Introduction to Statistical Quality Control**, Sixth Edition. John Wiley (2009).
- Eugene Grant, **Statistical Quality Control**, McGraw Hill Education; 7th Edition (2017)
- Acheson J Duncan, **Quality Control and Industrial Statistics**, R. D. Irwin; 4th Edition (1974).
- Burr, I. W., Statistical Quality Control Methods, Volume 16, New York: Marcel Dekker, Inc (1976).
- J.M. Juran, Frank M. Gryna, **Juran's Quality Control Handbook**, McGraw-Hill; 4th Edition (1988).

Paper OR22204 (B): STATISTICAL METHODS-I

UNIT –I:

Meaning and Scope of Statistics – Types of data – Methods for collecting the data, classification, Tabulation and Data interpretation.

UNIT – II:

Analysis of data – Measures of central tendency, Measures of dispersion – Measure of skewness, Basic probability - Addition and Multiplication Theorems.

UNIT-III:

Concept of Probability – Various Types of Events: Classical and Empirical Definitions of Probability – Laws of Addition and Multiplication of Probability (statements only)

UNIT – IV:

Correlation - Types of correlation – Karl Pearson's correlation coefficient – Rank correlation Regression – Regression lines – Regression equations - fitting of regression equations.

UNIT – V:

Distributions – Binomial Distribution – fitting of Binomial Distribution – Poisson distribution – Mean and variance of Poisson distribution - properties of Poisson distribution, Normal distribution – Mean and variance of Normal distribution properties of Normal distribution.

References:

Statistical Methods – S.P .Gupta – sultan chand & company, New Delhi.
Comprehensive Statistical Methods – P.N. Arora, Sumeet Arora and S. Arora – Sultan chand & company Ltd – New Delhi.

Internal Elective

Paper OR22204(C): MEASURE THEORY AND ADVANCE PROBABILITY

UNIT I

Class of sets, field, sigma field, minimal sigma field, Borel sigma field, sequence of sets and their convergence, measure, probability measure, properties of measure.

UNIT II

Borel-Cantelli lemma. Borel zero-one law. Caratheodory extension theorem (statement only), Lebesgue measure and Lebesgue-Stieljes measure.

UNIT II

Measurable functions, random variables, sequence of random variables, integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou's lemma. Dominated convergence theorem, Fubini's theorem (statement only).

UNIT III

Two dimensional and multidimensional random variables: Joint, Marginal and Conditional Distributions functions of random variables and transformation of random variables, Independence of Random Variables. Compound, Truncated and Mixture distributions

UNIT IV

Moments of Random Variables – Expectations, Variance, Covariance, Conditional and Marginal Expectations, Moment Inequalities of Hölder, Minkowski, Jensen's, Cauchy-Schwartz. Markov and Lyapunov's.

References

- Billingsley P., Probability and Measure, Wiley (1986).
- B.R. Bhat, **Modern Probability Theory**, New Academic Science; 4th Edition (2018).
- Rohatgi V.K., **An Introduction to Probability Theory and Mathematical Statistics**, Wiley-Blackwell (1976).
- A. M. Gun, M. K. Gupta, B. Dasgupta , **An Outline of Statistical Theory: Volume 1**, The World Press Private Ltd (2013).

Paper OR22301: INVENTORY & INFORMATION THEORY

Unit-I

Concept of Inventory – Costs associated with inventory – Classification of inventory models – deterministic inventory models with and without shortages.

Unit-II

Multi-item inventory model with constraint on Investment – Warehouse capacity and an average inventory EOQ models with quantity discounts and selection control techniques.

Unit-III

Probabilistic Inventory models – Instantaneous and uniform demand with and without setup cost models – (S, s) policy for inventory and its derivation in case of exponential demands.

UNIT-IV

Forecasting Models – Brown's Single and Double Exponential Smoothing Methods and their unbiased estimates.

Unit-V

Axiomatic approach to the concept of information and entropy – Properties of Shannon entropy of a discrete probability distribution – Joint Entropy – Conditional Entropies – Channel Capacity of a Discrete Memoryless Channel.

References

- S D Sharma, **Operations Research**, Kedar Nath Ram Nath Publications (2003).
- Hamdy A Taha, **Operations Research**: **An Introduction,** PEARSON Publications, 10th Edition (2017).
- Man Mohan, P. K. Gupta, Kanti Swarup, **Operations Research** , Sultan Chand & Sons (2014).
- B.S. Goel, S.K. Mittal, Sudhir K. Pundir, **Operations Research**, Pragati Prakashan Publications (2017).
- R.G. Brown, **Smoothing, Forecasting and Prediction of Discrete Time Series**, Prentice Hall (1963).
- Johnson, L.A. and Montgomery, D.C., **Operations Research in Production Planning, Scheduling and Inventory Control**, Wiley, New York (1974).
- Robert B. Ash, **Information Theory (Dover Books on Mathematics)**, Dover Publications; New edition edition (1990)

❖ Fazlollah M. Reza, **An Introduction to Information Theory**, Dover Publications Inc.; New edition edition (2003).

Paper OR22302: STATISTICAL QUALITY CONTROL - II

UNIT-I

The notion of Product Control –Lot by Lot Inspection by Attributes– acceptance sampling plans – OC curve of an acceptance sampling plan – Type-A, type-B O.C. curves – AQL, LTPD, Producer's and consumer's risk – Single and double sampling plans for fraction defectives with specified AQL, LTPD, Producer's risk (α) and consumer's risk(β).

UNIT-II

Acceptance Sampling by Variables- with Quality Characteristics Single Sampling Plan following Normal Distribution with specified P_1^1, P_2^1, α and β (with single and double specification limits when the process standard deviation is known).

UNIT-III

Rectifying Inspection for lot-by-lot sampling – Single Sampling Plan with Rectifications, AOQ, AOQL, ATI curves – Design SSP with rectification using LTPD and β – Item-by-Item SPR plans for continuous productions.

UNIT-IV

Sampling Plan for Continuous Inspection – Continuous sampling plans for inspection by attributes - Dodge, CSP -1, CSP-2 and Chain Sampling Plan - Wald-Wolfowitz and Gischile Plans.

References

❖ Acheson J Duncan, **Quality Control and Industrial Statistics**, R. D. Irwin; 4th Edition (1974).

❖ H F & Romig, H G Dodge, **Sampling Inspection Tables**, John Wiley and Sons (1967) .

❖ Irving W. Burr, **Statistical Quality Control Methods (Statistics: A Series of Textbooks and Monographs),** CRC Press, 1st Edition (1976).

❖ William C Guenther, **Sampling Inspection in Statistical Quality Control**, C. Griffin Publisher (1977).

❖ Walter A. Shewhart, **Statistical Method from the Viewpoint of Quality Control**, Dover Publications Inc. (2003).

❖ Dudley J. Cowden , **Statistical Methods in Quality Control**, Prentice-Hall, Inc; 1st edition (1957).

Compulsory Foundation

Paper OR22303(A): RELIABILITY THEORY

Unit-I

Reliability concepts and measures – life testing problems and procedures – chance and wear out failures and corresponding failure density function – Hazard functions and reliability function.

Unit-II

Estimation of Failure Density Parameters Interval Estimation of Reliability Function – General failure distributions – Exponential, Normal, Log-Normal, Gamma and Weibull laws – Estimation of parameters and tests in these models.

Unit-III

Reliability estimation based on failure times in various censored life tests and in tests with replacement of failure items.

Unit-IV

System Reliability – Series and Parallel configurations – k-out-of-n system – Markov models for System Reliability – Maintainability – System Availability measures – Reliability Allocation.

References

❖ E. Balaguruswamy, **Reliability Engineering**, McGraw Hill Education (2017).
❖ L.S.Sreenath, **Reliability Engineering**, East West Publications (2005).
❖ Arnljot Høyland, Marvin Rausand, **System Reliability Theory: Models, Statistical Methods, and Applications**, Wiley-Blackwell; 2nd edition (2004).
❖ S. K.; Kale, B. K. Sinha, **Life Testing and Reliability Estimation**, Wiley Eastern Limited (1980).
❖ Martin L. Shooman, **Probabilistic Reliability: An Engineering Approach**, Krieger Pub Co; Subsequent edition (1990).

Paper OR22303(B): SAMPLING SURVEY

Unit I

Concept of population and sample, need for sampling, review of simple random sampling (SRS), stratified random sampling, stratified sampling for proportions, ratio and regression methods of estimation, separate and combined ratio and regression estimators and comparison.

Unit Il

Systematic sampling, varying probability sampling (PPSWR/WOR methods): cumulative total method. Lahiri's method and related estimators of a finite population mean, Ordered estimator: Desraj's estimator for general sample size, Unordered estimator: Murthy's estimator for a sample of size 2.

Unit III

Horvitz-Thompson estimator, its variance and unbiased estimator of variance, sampling scheme due Sen-Midzuno, Rao-Hartley-Cochran random group method.

Unit IV

Equal size cluster sampling: estimators of population mean and total and their standard errors, comparison of cluster sampling with SRS in terms of intra-class correlation coefficient

Unit V

Sources of errors in surveys: Sampling and non-sampling errors, various types of non - sampling errors and their sources, estimation of mean and proportion in the presence of non-response. Hansen and Hurwitz technique, Optimum sampling fraction among non-respondents, randomized response technique: Warner's method: related and unrelated questionnaire methods.

References

- Chaudhuri, A. and Mukerjee, R. (1988): **Randomized Response: Theory and Techniques**. Marcel Dekker. Inc.. New York.
- Chaudhuri, A. (2011): **Randomized Response and Indirect Questioning Techniques in Surveys**, CRC Press.
- Cochran, W.G. (2007): **Sampling Techniques**, Third Edition, Wiley
- Raj. D. and Chandhok, P. (2013): **Sample Survey Theory**, Create Space Independent Publishing Platform.

Open Elective

Paper OR22304(A): R PROGRAMMING

UNIT I

Introduction to R software, installation procedure. packages library. R-Studio.

Data:-R as calculator, Assignment, using c ( ) to enter data, using functions on data. Creating structured data, accessing data by using indices, assigning values to data vector, logical values, missing values. Reading in other sources of data.

Univariate data: categorical, Bar plots, misleading bar plots. Pie charts, Dot charts. Factors. stem-and-leaf plots strip charts, the centre (mean, median, mode), variation (variance. standard deviation. IQR) Histogram, frequency polygon.

Unit Il

Bivariate data: Making two-way tables data, marginal distributions of two-way tables. Conditional distribution of two-way tables, graphical summaries of two-way tables. Comparing independent samples: by side-by-side box plots, density plots, strip charts. quantile-quantile plots (q-q plots), correlation(Person and Spearman Rank), simple linear regression.

Multivariate data: summarizing categorical data, comparing independent samples.

Data frames and lists, creating data frame & list, accessing values in a data frame, accessing a data frame with logical vectors, sorting a data frame, setting values in a data frame or list. Applying functions to a data frame or list.

Unit III

Describing populations: random variables, specifying distribution, using sample© to generate random values, random samples generated by sample ( ). The d, p. q and r functions. Basic distributions : Binomial, normal. uniform, exponential, lognormal. Central limit theorem. normal approximation to the binomial distribution.

Unit IV

Simulation: normal approximation for the binomial, for LOOPS. simulation related to the central limit theorem, defining a function, editing a function, function arguments, function body. Investigating distributions, comparing measurements of spread. Script Miles and source ( ). Bootstrap samples Alternative to FOR LOOPS.

Random number generation by inverse transformation method.

References

- W. John Braun and D. J. Murdoch (2007) : **A first course in statistical programming with R. parametric inference**. Cambridge University Press.
- H. Niederreiter (1992): **Random number generation and quasi-Monte Carlo methods**. Austrian academy of sciences.
- P. N. Tattar, S. Ramaiah and B.G. Manjunath (2016): **A Course in Statistics With R**. John Wiley Sons. Lid.
- Garth James. Daniela Witten. Trevor Hastie. Robert Tibshirani (2017): **An Introduction to Statistical Learning with Applications in R**. Springer.

Open Elective

Paper OR22304(B): STATISTICAL METHODS-II

UNIT –I:

Concept of sampling – Sampling and Non-Sampling Errors – Types of sampling – Simple Random sampling, stratified Random sampling and systematic sampling – their Applications.

UNIT – II:

Analysis of variance – One way and Two way classifications parametric versus Non-parametric tests – Experimental Designs – Completely Randomized Design and Randomised Block design.

UNIT – III:

Testing of hypotheses – Two types of errors – one and Two – tailed tests – Tests of significance – Large sample and small sample tests – Student's t – test, chi-square test – Uses of chi-square –test – chi-square – test for contingency tables.

UNIT – IV:

Time series Analysis – Components of time series – Measurement of Trend – Method of semi averages – Method of moving averages – Method of least squares – fitting of a straight line – Trend values.

UNIT – V:

Concept of Index Numbers–Uses and Construction of Index Numbers–Simple and Weighted Index Numbers – Laspeyer's, Paasche's and Fisher's Methods

REFERENCES:

Statistical Methods – S.P .Gupta – sultan chand & company, New Delhi.
Comprehensive Statistical Methods – P.N. Arora, Sumeet Arora and S. Arora – Sultan chand & company Ltd – New Delhi.

Paper OR22401: QUEUING THEORY AND NETWORK ANALYSIS

Unit – I

Elements of Queuing Theory – Characteristics of Queuing system – Classification of Queuing and Probability distribution of arrivals and inter-arrival times – M/M/I & M/M/C with finite and infinite capacities, Queue Discipline with Queue Characteristics – Birth and Death Processes and its applications.

Unit – II

Non-Poisson Queuing System – ELarnagian service time distributions $(M/E_k/1):(\infty/FIFO)$ and $(M/E_k/1):(1/FIFO)$with its characteristics – M/G/1 Queuing system with Embedded Markov Chain Technique – Definition of Bulk and Priority Queues.

Unit – III

Introduction to Network Analysis – Definition of a Project, Job and Events – Drawing of Arrow Diagrams – Determination of Critical paths and calculation of floats – Resource allocation and least cost planning – Uncertain duration's PERT/CPM system and installation of a network system.

Unit – IV

Network flow problems and finding maximal flows – Combinatorial extensions – Minimal Cost flow problems and applications – Travelling Salesman problem.

References

- C. West Churchman, Russell L. Ackoff, E. Leonard Arnoff, **Introduction to Operations Research**, John Wiley & Sons (1959).
- Thomas L. Saaty, **Mathematical Methods of Operations Research**, Dover Publishers (1989).
- Maurice Sasieni, Arthur Yaspan, Lawrence Friedman, **Operations Research: Methods and Problems**, Literary Licensing, LLC (2013).
- Harvey M. Wagner, **Principles of Operations Research: With Applications to Managerial Decisions**, Prentice Hall; 2nd Edition (1975).
- Wah Chun Chan, **An Elementary Introduction to Queuing Systems**, World Scientific Publishing Co., Pvt. Ltd., (2014).
- D. R. and Walter L. Smith Cox, **Queues**, Mathuen & Co (1961).
- S D Sharma, **Operations Research**, Kedar Nath Ram Nath Publications (2003).

Paper OR22402: MATHEMATICAL PROGRAMMING – II

Unit-I

Elements of Game Theory – Two person zero sum game – pay-off matrix – pure and mixed strategies – saddle point – minimax principle – rectangular games with and without saddle point – Dominance property – reducing of a two person zero sum game to a linear program – Fundamental theorem of rectangular games – graphical method for solution of a game – iterative technique for an approximate solution of a game.

Unit-II

Criteria for investment decision – Present value method – The concept of depreciation models consideration leading to replacement – Group vs. Individual replacement policies – replacement of items that fail when the value of money remains unchanged and when the value of money changes with time – Break down and preventive replacement.

Unit-III

Problems of sequence – measures of schedule and evaluation – finite sequencing for a single machine – 2 machines and n jobs – no. passing and K machines and n-jobs no passing – different routing – the general n x m job shop problem – Branch and Bound Algorithm for flow shop scheduling.

Unit-IV

Simulation – Concept of simulation – Advantages and Limitations of Simulation – Monte Carlo techniques for queuing, inventory and sequencing models.

References

- Churchman and Arnof : Introduction to Operations Research
- Owen A(1968) : Game Theory, Samders
- Thomos L.C(1984) : Game Theory and its applications, John Wiley
- Luce R and Raiffa : Games and Decisiions
- Wagner H.M : Principles of O.R., Prentice-Hall of India
- Vaida S : The theory of Games and LPP
- Sasieni, Yaspina & Friedman : Operations Research-Methods & Problems
- Hamdy A.Taha (5th edition) : Operations Research-An Introduction
- Sharma J.K : Operations Research Theory & Application, Chapter 28

Elective Foundation

Paper OR22403(A): MULTIVARIATE ANALYSIS

Unit-I

Multivariate Normal Distribution, marginal and conditional distributions, characteristic functions, Maximum likelihood estimators of parameters, distribution of sample mean vector and dispersion matrix, distribution of quadratic form in the exponent of the multivariate normal density.

Unit-II

Hotelling's T^2 and its applications – T^2 distribution, application of T^2 to single sample, two sample and multiple sample problems, optimum properties of T^2 test. Mahalobis D^2 statistic and its distribution, Multivariate Analysis of Variance (MANOVA) of one and two-way classified data.

Unit-III

Classification and discrimination: procedures for classification into two multivariate normal populations, Fisher's Discriminant function, classification into more than two multivariate normal populations, Wishart distribution and its properties, concept of sample generalized variance and its distribution.

Unit-IV

Principal Component Analysis – properties, method of extraction of principal components; Canonical variables and canonical correlations.

UNIT-V

Factor Analysis – mathematical model, estimation of factor loading, concept of factor rotation; Cluster Analysis – similarities and dissimilarities, Hierarchical clustering: single and complete linkage method.

References

- ANDERSON, T.W, **AN INTRODUCTION TO MULTIVARIATE STATISTICAL ANALYSIS**, WILEY, 2ND EDITION(1983).
- RAO, C.R, **LINEAR STATISTICAL INFERENCE AND ITS APPLICATIONS**, 2ND EDITION, WILEY (1973).

Elective Foundation

Paper OR22403 (B): DATA MINING

UNIT – I

Data Mining – Meaning, Data Mining Functionalities classification – Data Mining Task Primitives – Integration of a Data Mining System with a Database – Major issues in Data Mining

UNIT – II

Descriptive Data Summarization – Data Cleaning, Data Integration and transformation, Data reduction, Data Discretization and concept Hierarchy Generation.

Unit-III

What is Data Warehouse? Multidimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, From Data Warehouse to data mining.

UNIT – IV

Basic Concepts of frequent patterns, Frequent Item sets, mining methods, Association rules, what is classification and Prediction, Classification By decision Tree Induction, Bayesian Classification, and Rule - Based Classification.

UNIT – V

Cluster analysis– Meaning, Types, Partitioning methods, Hierarchical methods, Density Based methods, Grid Based methods, and Model-Based Clustering methods, Outlier analysis

References

- DATA MINING CONCEPTS & TECHNIQUES BY JIAWEI HAN, MICHELINE & KAMBER (2ND EDI.) MORGAN KAUFMANN PUBLISHERS (ELSEVIER)
- DATA MINING INTRODUCTORY AND ADVANCED TOPICS –MARGARET H DUNHAM, PEARSON EDUCATION
- DATA MINING TECHNIQUES – ARUN K PUJARI, UNIVERSITY PRESS
- DATA WAREHOUSING IN THE REAL WORLD –SAM ANAHORY & DENNIS MURRAY PEARSON EDN ASIS.
- THE DATA WAREHOUSE LIFE CYCLE TOOL KIT – RALPH KIMBALL WILEY STUDENT EDITION

Generic Elective

Paper OR22404 [A]: QUANTITATIVE POPULATION STUDIES

UNIT-I

Measures of Population Change and Distribution: Rate of population change, exponential and logistic growth models; population density, population potential; Measures of age distribution: index of relative difference, index of dissimilarity; Measures of ageing.

UNIT-II

Measures of mortality: Crude death rate, age specific death rates, cause specific death rates and ratios, Infant mortality rate, neonatal mortality rate, post-neonatal mortality rate, endogenous and exogenous mortality rates, maternal mortality ratio, standardization of death rates, comparative mortality index.

UNIT-III

Life Tables: Period life table and cohort life table; Components of a life table; Construction of life tables.

Fertility: Crude birth-rate, general fertility rate, age-specific fertility rates, total fertility rate, age-cumulative fertility rate; Age-sex adjusted birth rates, indices of fertility, fertility rates specific of order of births, net reproduction rate.

Migration: Definitions, concepts, measures of internal migration and international migration.

UNIT-IV

Population Data Laboratory: Exercises on population projection, population growth models, life table construction, measuring fertility, mortality and migration.

References

- Bhende, A. A., and Kanitkar, T. (2011), **Principles of Population Studies,** Himalaya Publishing House, Mumbai.

Generic Elective

Paper OR22404(B): TOTAL QUALITY MANAGEMENT

UNIT – I

Definitions of quality – Dimensions of product and service quality – Basic concepts of TQM – TQM Framework, Axioms, benefits - Barriers to TQM – Contributions of Deming, Juran and Crosby - Deming's Fourteen Points for Management - Deadly Sins & diseases.

UNIT – II

Concepts of Quality circle - Continuous process improvement – PDCA cycle. The Juran Quality Trilogy - Juran Ten Steps to Quality improvement - Crosby defined Four Absolutes of Quality Management .

UNIT – III

Management Methods: Cost benefit Analysis, Deming Wheel, ISO 9000, Just-in-time, Kaizen.

Analytical Methods: Cause and Effect Analysis, Hypothesis testing, Paired Comparisons, Design and Analysis of Experiments – Factorial experiments – Fractional designs, Robust Design, Taguchi Methods.

UNIT – IV

Idea Generation: Brainstorming, list of reduction, mind mapping, idea writing.

Data Collection & Display Method: Flow Charts, Bar charts, Histogram, Scatter Diagram, Basic Statistics - Measures of Central Tendency & Dispersion, Statistical Process control, Control charts – Variable & Attribute charts, Interpretation of Control charts, CUSUM charts

References

- "QUALITY IN TOTALITY", PARAS DIWAN, DEEP & DEEP, NP.
- "MANAGING FOR TOTAL QUALITY", N.LOGOTHETIS, PHI PUBLICATIONS.
- "TOTAL QUALITY" : BHARAT WAKHLAN, WHEELEN, ND.
- "TQM-TEXT, CASES AND READINGS", JOEL E.ROSS, DEEP & DEEP ND
- "100 METHODS FOR TOTAL QUALITY MANAGEMENT": GOPAL K.KANJI & MIKE ASHER