INDIAN STATISTICAL INSTITUTE

Students' Brochure
PART II

Master of Science in Quality Management Science

(Effective from 2014-15 Academic Year)

(See PART I for general information, rules and regulations)

The Headquarters is at
203 BARRACKPORE TRUNK ROAD
KOLKATA 700108

INDIAN STATISTICAL INSTITUTE

Master of Science in Quality Management Science

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1 Curriculum

This two-year programme consists of *15 compulsory courses, 2 elective courses and a dissertation* in the first three semesters, and a *live project work* during the fourth semester. The first two semesters will be offered at *Bengaluru* whereas the third semester will be at *Hyderabad*. The project work in the fourth semester will be at respective locations of internship. The courses other than dissertation and project are allocated *four* hours per week. The structure given below follows the sequencing approved in the 60th meeting of the Academic Council.

First Year

Semester I (600 marks)	Semester II (600 marks)
Statistics for Decision Making I	Statistics for Decision Making II
Statistical Process Control	Advanced Statistical Process Control
Reliability, Maintainability and Safety I	Reliability, Maintainability and Safety II
Operations Research I	Operations Research II
Project Management	Multivariate Data Analysis
Total Quality Management	Elective I

Second Year

Semester I (600 marks)	Semester II (200 marks)
Applied Regression Analysis	Project Work
Non-linear Programming	
Industrial Experimentation	
Six Sigma – Business Excellence Strategy and Problem Solving Framework	
Elective II	
Dissertation	

Elective Courses*

Elective I	Elective II
Game Theory	Quality Audit
Capability Maturity Models	Supply Chain Management
Marketing Research	
Data Base Management	
Pattern Recognition	
Neural Networks	
Trouble Shooting and Problem Solving for Quality Improvement	
Measuring Customer Satisfaction	
Software Reliability	
Human Factors in Continuous Improvement	
Markov Analysis and Modelling	

*Whether a particular elective course is offered in a given semester will depend on students' interest and availability of teachers.

2 Detailed Syllabi of Courses

The number shown in parentheses after a particular topic indicates the suggested number of lectures allocated to that topic.

2.1 First Semester Courses

Statistics for Decision Making I

1. Introduction (2)

   Definition of 'Statistics', Descriptive and Inferential Statistics, Basic Objectives, Applications to various disciplines with examples, Impact of Computer on data analysis.

2. Collection of Data (3)

   Internal and external data, Primary and secondary Data, Population and sample, 'Representative' sample, Types of data – continuous and discrete data, Planning and execution of data collection, errors in the process of data collection.

3. Descriptive Statistics (22)

   Scrutiny, classification and tabulation of univariate data, Graphical representation, Frequency distribution, Histogram, Box Plot, Dot Plot, Pareto Diagram. (5)

Descriptive measures – central tendency and dispersion. Skewness and Kurtosis of a frequency distribution. (5)

Bivariate data, Summarization of bivariate data, Marginal and conditional frequency distribution, Scatter diagram, Linear regression and correlation, Least squares method, Rank correlation, Association of attributes. (7)

Multivariate data, multiple linear regression, multiple and partial correlation, Coefficient of multiple determination. (5)

4. Simulation of Probability models (8)

   Random numbers and pseudorandom numbers, Generation of random samples from Uniform, Normal, Bivariate Normal, Exponential, Gamma, Poisson and other distributions.

5. Sampling Techniques (10)

   Random sampling, Bias and its sources, Sampling from finite and infinite populations, Estimates and standard error (sampling with replacement and sampling without replacement), Sampling distribution of sample mean, Stratified random sampling, proportional and optimum allocation, Systematic sampling, Cluster Sampling.

6. Sampling distribution (10)

   Sampling distributions related to standard univariate probability models – Binomial, Poisson, Normal, Exponential, Gamma, etc.

For all the topics above: Examples and Exercises with use of software packages like Minitab / JMP/ SPSS/ Statistica/ Systat/excel etc.

References

1. *Probability and Statistics for Engineers* (7th Edition), I. Miller, J. Freund and R.A. Johnson, Prentice Hall, 2005.

2. *Statistical Theory with Engineering Application*, A. Hald, Textbook Publishers, 2003.

3. *Statistical Concepts and Methods*, G.K. Bhattacharyya and R.A. Johnson, Wiley, 1977.

4. *Introduction to Linear Regression Analysis*, D.C. Montgomery , E.A. Peck and G.G. Vining, Wiley, 2006.

5. *Introduction to the Theory of Statistics*, A.M. Mood, F.A. Graybill and D.C. Boes, Tata McGraw–Hill, 1974 (RP 2008).

6. *Applied Regression Analysis*, N. R.Draper and H. Smith, Wiley, 1981.

7. *Basic Statistics*, Dick A. Leabo, C. Frank Smith, R. D. Irwin, 1968.

8. *Beginning Statistics*, R. Lowell Wine, Winthrop Publishers, 1976

9. *Operations Research – An Introduction*, Hamdy A. Taha, Prentice Hall, 1997.

Statistical Process Control

1. Introduction to SPC (2)

   Concept of quality, Quality control and Quality improvement; Role of SPC in this context, Concept of variation due to common and assignable causes; meaning of control, expected benefits of SPC.

2. Control Charts (20)

   (a) Introduction to Shewhart Control charts, Statistical basis for control charts, Control chart for variables and attributes: X–MR, $\bar{X}$–R, $\bar{X}$–s, np, p, c, u charts.

   (b) Sloping control chart, Modified control charts, CUSUM chart, EWMA chart, Pre-control chart, Run Chart.

   (c) Usage of statistical software (like Minitab, SPSS, Systat, Statistica, JMP etc) for construction of control chart with live data.

3. Process Capability Analysis (6)

   (a) Process capability Analysis, process capability and machine capability indices (C_p, P_p, C_{pk}, P_{pk})

   (b) Estimation of process capability indices for live data by statistical software (like Minitab, SPSS, Systat, Statistica, JMP etc)

4. Measurement System Analysis (12)

   (a) Measurement system analysis – Definition of bias, linearity, stability, repeatability and reproducibility. Selection of appropriate gauge for measurement purpose.

   (b) Estimation of measurement error (Repeatability and Reproducibility) for variable data by ANOVA and Control Chart method

   (c) Estimation of Kappa for attribute data.

(d) Usage of statistical software (like Minitab, SPSS, Systat, Statistica, JMP etc) for estimation of Gauge R & R and Kappa values from live data.

5. Acceptance Sampling (15)

   (a) Purpose of sampling inspection, Critique of acceptance sampling, Relevance of sampling inspection in today's techno-economic scenario

   (b) Concept and definitions: Single Sampling, Double Sampling, Multiple sampling plans, AQL, LTPD, Type A and Type B OC function, ASN, AOQL and ATI for acceptance rectification plans

   (c) Sampling Schemes: Dodge and Romig's system of AOQL and LTPD plans; Sampling plans based on OC functions; Military Standards (105 D and 105 E).

References

1. *Introduction to Statistical Quality Control* (5th Edition), D.C.Montgomery, Wiley, NY.

2. *Statistical Quality Control* (6th edition), E.L. Grant and R.S. Leavenworth, McGraw-Hill, NY.

3. *Quality Control and Industrial Statistics* (5th edition), A.J. Duncan, Irwin, Homewood, IL.

4. *Quality Control and Statistical Methods*, Edward M. Schrock, Asia Publishing House.

5. *Statistical Process Control – Theory and Practice*, By G.B. Wetherill and D.W. Brown, Chapmann & Hall, NY.

6. Single sampling and double sampling inspection tables, *Bell Syst. Tech. J.*, vol.20, pp.1-61, Dodge, H.F. and Romig, H.G., 1941; reprinted in Dodge, H.F. and Romig, H.G., *Sampling Inspection Tables* (2nd edn), Wiley, NY, 1959.

7. *Sampling Procedures and Tables for Inspection by Attributes*, MIL-STD-105D, U.S. Government Printing Office, Washington DC, 1963.

Reliability, Maintainability and Safety I

1. Probability (38):

   (a) Concept and Definition (8)

   Sample space and events; basic properties with union and intersection of events; conditional probability – Bayes' rule.

(b) Discrete random variables (12)

Binomial, Geometric, Negative Binomial, Poisson; Poisson approximation to Binomial distribution; independent random variables and their sum; moments-expectation, variance; Chebychev's inequality.

(c) Continuous random variables (12)

Distribution function and density function; Uniform, Normal, Exponential, Gamma, Weibull – their moments; change of variable formula.

(d) Jointly distributed random variables (6)

Conditional distribution; correlation coefficient; order statistics; Central Limit Theorem.

2. Reliability, Maintainability and Safety (17)

(a) Concept of Reliability (2)

Definition of reliability and related measures; concept of failure; quality and reliability; importance of reliability.

(b) Failure Patterns – Probability Models (5)

Hazard models - bath tub curve; causes of early failure; failure-time distributions: exponential, Weibull, normal, log-normal, gamma; their properties and uses.

(c) System Reliability Computation (10)

Series, parallel, series-parallel, bridge and r-out-of-n configurations: reliability block diagram; determination of reliability through combinatorial methods of inspection, events space, cut set and tie set; strength and stress distribution - safety factor and reliability.

References

1. *Introduction to Probability Theory*, Hoel P.G., Port S.C. and Stone C.J. (1971), Houghton Mifflin Company.

2. *An Introduction to Probability Theory and its Applications (Vol. I)*, Feller W. (1957), John Wiley & Sons.

3. *An Introduction to Probability Theory and its Applications (Vol. II)*, Feller W. (1966), John Wiley & Sons.

4. *A first Course in Probability*, Ross S.M. (2005), Prentice Hall.

5. *Reliability in Engineering Design*, Kapur K.C. and Lamberson L.R. (1977), John Wiley & Sons.

6. *Statistical Methods for Reliability Data*, Meeker W.Q. and L.A. Escobar L.A. (1998), John Wiley & Sons.

7. *Statistical Models and Methods for Lifetime Data*, Lawless J.F. (1982), John Wiley & Sons.

8. *System Reliability Theory*, Høyland A. and Rausand M. (1994), John Wiley & Sons.

Operations Research I

1. Introduction to OR (1)

   Origin of OR and its definitions – Operational Research with special emphasis on interdisciplinary and systems approach, stages of OR project, problem formulations. Developing a model. Testing the adequacy of the model, deriving a solution and evaluation of the solution and implementation.

2. Linear Programming (30)

   Linear programming – examples and modeling. LP formulations using matrix notation, standard and canonical forms, row operations, pivoting. Polyhedral sets, extreme points, bases and the connection between extreme points and the bases. Graphical method for solving LPs. Existence of optimal basic feasible solutions. The simplex methods: two-phase and the big-M method. Degeneracy in LP and its resolution. The revised simplex method and its significance. Duality: formulations, the fundamental theorem of duality, the dual simplex algorithm, and the sensitivity analysis.

3. Applications of OR (20)

   The minimum cost network flow problems, the transportation model, and the bounded variables problem. Large scale optimization problems and the decomposition principle. Case studies on industrial applications of OR.

References

1. *Operations Research and Management Science, Hand Book*, A. Ravi Ravindran (editors), CRC Press, Taylor & Francis.

2. *Nonlinear Programming — Theory and Algorithms* (second edition), Mokhtar S. Basaraa, Hanif D. Sherali and C.M. Shetty, John Wiley & Sons, New Delhi.

3. *Network Programming*, Katta Murty, Prentice Hall.

4. *Handbook of Applied Optimization*, Panos M. Pardalos and Mauricio G.C. Resende (editors), Oxford University Press.

5. *The Linear Complementarity Problem*, Cottle, Pang and Stone, Academic Press.

Project Management

1. Project Management Framework (8)

   Introduction on Project Management, Project Management Lifecycles, Stakeholders, Project Management Processes, & its interactions, Organizational Influences, Project Management Process Mapping.

2. Project Integration Management (8)

   Project Planning, Project Execution, Monitoring and Control, Project Change Management, Project Closure.

3. Scope Management (3)

   Scope Planning, Scope Definition, Scope Verification and Control.

4. Time Management (4)

   Activity Definition, Activity Sequencing, Activity Duration Estimation, Schedule Development and Control.

5. Cost Management (5)

   Cost Estimating, Cost Budgeting, Cost Control.

6. Quality Management (5)

   Quality Planning, Quality Assurance, Quality Control.

7. Human Resource Management (3)

   HR Planning, Acquire, Develop Manage Teams.

8. Communication Management (4)

   Communication planning, Information Distribution, Performance Reporting.

9. Risk Management (6)

   Risk Planning, Risk Identification, Risk Analysis, Risk Management.

10. Procurement Management (4)

    Procurement Planning and Acquisition, Source Selection, Contract Management.

11. Advanced techniques in Project Management (10)

    PERT/CPM, Sequencing and Scheduling, Dependency Structure Matrix Analysis, M7 tools, Decision Analysis.

References

1. *The Art of Project Management Theory in Practice*, Scott Berkun, O'Reilley, 2005.
2. *Project Management: A Systems Approach to Planning, Scheduling and Controlling*, Herold Kerzner, John Wiley & Sons, 2009.
3. *Fundamentals of Project Management*, James P. Lewis, American Management Association, 2007.
4. *Project Management: A Managerial Approach*, Jack R. Meredith and Samuel J. Mantel, John Wiley & Sons, 2009.
5. *Project Management: 24 steps to help you master any project*, Gary R. Heerkens, McGraw-Hill 2007.

Total Quality Management

1. Quality Management (10)

   Basic concepts. Elements of Quality and Management Quality policies and goals. Economics of Quality.

2. Organising for Quality (10)

   Evolution of organisation for quality, co-ordination of quality activities, role of upper management, middle management, work force and teams. Self managing teams, quality circles.

   Culture, Motivation, Creating and maintaining quality awareness, Achieving total commitment to quality-various approaches.: Juran, Deming, Ishikawa and Taguchi

3. TQM Principles (10)

   Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Employee Involvement – Motivation, Empowerment, Continuous Process Improvement – 5S, Kaizen, Supplier Quality – Partnering, sourcing, Supplier Selection, Supplier Rating.

4. TQM TOOLS (15)

   Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept.

5. Quality Management and Assurance systems (10)

   Developing and establishing quality management and assurance system. Basics of ISO 9000, TS 16949, ISO 14000 systems, Quality Audit, Accreditation systems.

References

1. *Quality Planning and Analysis*, J.M. Juran and F.M. Gryna, Tata McGraw Hill.
2. *Total Quality Control*, A.V. Feigenbaum, McGraw Hill.
3. *Quality Handbook*, J.M. Juran (Ed.), McGraw Hill.
4. *Total Quality Management- A Practical Approach*, H. All, Wiley Eastern.
5. *Handbook of Quality Management*, D.Lock (Ed.), Jaico.
6. *ISO 9001,14001 & TS 16949 Quality Assurance System Standards*.

2.2 Second Semester Compulsory Courses

Statistics for Decision Making II

1. Introduction (2)

   Principles of Statistical Inference. Formulation of the problems with examples.

2. Estimation (8)

   Point estimation, Estimator and Estimate, Criteria for good estimates- Unbiasedness, Consistency, Efficiency and Sufficiency, Illustrations. Methods of estimation of Parameters of standard distributions. Interval estimation by examples- Confidence internals of the parameters of the standard distributions. Estimation using Statistical Software.

3. Testing hypothesis (20)

   Formulation of the problem and concepts for evaluation of tests, Illustrations. Statistic, Sampling distributions of statistic and its Standard Error.

Large sample tests in one and two-sample problems of standard probability distributions, Statement of central limit theorem, Determination of sample size. Simple linear regression and correlation and corresponding confidence intervals. Transformation of statistics to stabilize the residual plots. Assessment of the model. Fitting of non-linear regression using transformation. Analysis of categorical data. Pearsonian chi-square and its applications. Test of hypothesis using Statistical Software.

4. Linear Statistical Models (10)

   Definition of linear model, interactions with illustrations. One way and two way analysis of variance. ANOVA using Statistical Software.

5. Non-parametric Inference (10)

   Comparison with parametric inference, Use of order statistics. Sign test, Wilcoxon signed rank test, Mann-Whitney test, Run test, Kolmogorov-Smirnov test. Spearman's and Kendall's test.

6. Usage of statistical software (5)

References

1. *Probability and Statistics for Engineers* (8th Edition), I.R. Miller, J.E. Freund and R. Johnson, Prentice-Hall, 2009.

2. *Fundamentals of Statistics (vol.I and vol. II)*, A. Goon, M. Gupta and B. Dasgupta, World Press.

3. *Statistical Theory with Engineering Application*, A. Hald., Wiley.

4. *Statistical Methods*, G.W. Snedecor and W.G. Cocharan, Affiliated East-West Press.

5. *Statistical Concepts and Methods*, G.K. Bhattacharya and R.A. Johnson,n Wiley.

6. *Introduction to Linear Regression Analysis*, D.C. Montgomery and E. Peck, Wiley.

7. *Introduction to the Theory of Statistics*, A.M. Mood, F.A. Graybill and D.C. Boes., Tata-McGraw Hill.

8. *Practical Non-Parametric Statistics*, W.J. Conover, Wiley.

9. *Applied Regression Analysis*, N. Draper and H. Smith, Wiley.

10. *Introduction to Statistical Quality Control*, D.C. Montgomery, Wiley.

Advanced Statistical Process Control

1. Advanced SPC Techniques (30)

   Dominance System – Concept of Process and dominance patterns with examples, also explain the different types of process control techniques to be used in each case with examples and exercises. Process Capability calculation for Non-Normal, Clemant's method.

   Implementing Control Chart and Out of Control Action Plan – Steps for implementation of control chart for on line process monitoring with out of control action plan.

   Group control chart for multiple stream processes.

   Control chart for short run processes.

   Interface and integration between SPC and EPC (Engineering Process Control).

   Multivariate Control Chart – Formation, examples with exercise.

2. Taguchi's On line QC Technique (10)

   Taguchi's Loss Function and quality level – definition and calculation of loss function for different types of quality characteristics.

   On line quality control system and method of process improvement – calculation of beta correction factor by ANOVA method and implementation of the same with examples and exercises.

3. Acceptance Sampling (15)

   Continuous Sampling Plans (CSP-1, CSP-2), Multilevel Plans.

   Special purpose plans – Chain Sampling and Skip lot sampling plans.

   Introduction to Bayesian sampling plans -use of past data.

   Using Military standards for multiattribute situation – recent developments.

References

1. *Introduction to Statistical Quality Control*, D.C. Montgomery 4th Edition, John Wiley.

2. Multivariate Q C, In *Encyclopedia of Statistical Sciences Vol. 6*, W.L. Johnson, S. Kotz (editors), John Wiley.

3. *Quality Control and Industrial Statistical* (5th Edition), A.J. Duncan, Irwin, Homewood, IL.

4. *Principle of Quality Control*, Jery Banks, John Wiley.

5. *Encyclopedia and Handbook of Process Capability Indices - A Comprehensive Exposition of Quality Control Measures*, Series on Quality, Reliability and Engineering Statistics Vol. 12, W.L. Pearn and Samuel Kotz, World Scientific Publishing Co. Pte. Ltd.

Reliability, Maintainability and Safety II

1. Reliability Improvement and Redundancy (10)

   Usefulness of redundancy; redundancy in system (with exponential components): parallel, r-out-of-n system, standby, shared load.

2. Reliability Testing Demonstration and Acceptance (15)

   Life testing methods; estimation of parameters and reliability with standard probability models using complete and censored samples; properties of these estimators; confidence intervals; probability plot and graphical procedures for estimating the parameter; validation of model; life test acceptance sampling plans in exponential case; sequential life test in exponential case; non-parametric estimation of reliability.

3. Reliability of Repairable System (8)

   Types of repair: good-as-new, minimal; modeling failure processes: renewal process, Poisson process, non-homogeneous Poisson process.

4. System Effectiveness Measures (3)

   Serviceability, maintainability, repairability, availability, operational readiness; reliability and maintainability trade-off. 5. Fault Tree Analysis (5) Event tree; simple fault tree and its construction; mathematics of FTA; FMEA; carrying out FMEA with practical example.

5. Accelerated Life Test (4)

   Need for accelerated life test (ALT); acceleration factor and method: use-rate, temperature, voltage; Arrhenius model, Erying model, inverse power model.

6. Warranty Analysis (10)

   Role of warranty; quality improvement versus warranty; free-replacement warranty (FRW) and pro-rated warranty (PRW); warranty policy and cost; analysis of warranty policy – some simple cases; automobile warranty (two-dimensional).

References

1. *Reliability in Engineering Design*, Kapur K.C. and Lamberson L.R. (1977), John Wiley & Sons.

2. *Repairable System Reliability*, Ascher H. and Feingold H. (1984), Marcel Dekker.

3. *Statistical Methods for Reliability Data*, Meeker W.Q. and L.A. Escobar L.A. (1998), John Wiley & Sons.

4. *Warranty Cost Analysis*, Blischke W.R. and Prabhakar Murthy D.N. (1994), Marcel Dekker.

5. *Concepts in Reliability*, Srinath L.S. (1975), Affiliated East-West Press.

6. *System Reliability Theory*, Høyland A. and Rausand M. (1994), John Wiley & Sons.

7. *Statistical Theory of Reliability and Life Testing*, Barlow R.E. and Proschan F. (1975), Holt, Rinehart and Winston.

Operations Research II

1. Integer Linear Programming (10)

   Introduction to ILP, formulation, branch and bound and cutting plane methods for solving ILPs. Applications of ILP: assignment problem, traveling salesman problem, cutting stock and material optimization problems.

2. Dynamic Programming (3)

   Deterministic dynamic programming problems, Bellman's optimality principle, forward and backward approaches for solving dynamic programming problems.

3. Queueing Theory (10)

   Introduction to waiting line models, steady state behavior of M/M/1, M/M/C queues, the problem of machine interference problem and use of finite queueing tables, introduction to M/G/1 and M/G/C models.

4. Inventory Control (10)

   Introduction; Design of inventory systems; Deterministic inventory systems; Stochastic inventory systems; Inventory control at multiple locations; Inventory management in practice.

5. Project Management (7)

   Introduction; Critical path method; PERT network analysis; Statistical analysis of project duration; Precedence diagramming method; Software tools for project management.

6. Simulation (8)

   Introduction; Basics of simulation; Simulation languages and software; Simulation projects.

7. Multiple Criteria Decision Making (12)

   Basic concepts; Multiple criteria methods for finite alternatives; Multiple criteria mathematical programming problems; Goal programming; Method of global criterion and compromise programming; Interactive methods; applications and software.

References

1. *Operations Research and Management Science, Hand Book*, A. Ravi Ravindran (editor), CRC Press, Taylor & Francis.

2. *Nonlinear Programming -– Theory and Algorithms* (second edition), Mokhtar S. Basaraa, Hanif D. Sherali and C. M. Shetty, John Wiley & Sons.

3. *Network Programming*, Katta Murty, Prentice Hall.

4. *Handbook of Applied Optimization*, Panos M. Pardalos and Mauricio G.C. Resende (editors), Oxford University Press.

5. *The Linear Complementarity Problem*, Cottle, Pang and Stone, Academic Press.

Multivariate Data Analysis

1. Analysis of Multivariate data (5)

   Multivariate data – summarization, Plots. Univariate and multivariate analyses – similarities. Special problems associated with multivariate analysis – Dimensionality reduction.

2. Multivariate normal distribution (9)

   Elementary properties. Inference on mean vectors in multivariate populations - Mahalanobis D^2, Hotelling's T^2, MANOVA.

3. Principal Component Analysis (4)

   PC Analysis based on the population covariance matrix, based on the sample covariance matrix; use of principal components.

4. Factor analysis (5)

   Loading, communality, variance of a factor and total variance; estimation of Parameters, choosing number of factors; selection of loading – rotation.

5. Discriminant Analysis and classification (6)

   Fisher's discriminant function,classification rule based on expected cost of misclassification; rule for classifying into two normals/K normals.

6. Cluster analysis, Multidimensional scaling, Correspondence analysis (7)

   Similarity measures, clustering methods and algorithms; multidimensional scaling – basic algorithm; correspondance analysis – algebraic development, inertia, interpretation.

7. Conjoint analysis (6)

   Introduction, methods.

8. Methods for multivariate SPC (7)

   Multivariate control charts, Multivariate process capability analysis.

9. Multivariate Linear Regression (7)

   Multivariate Linear Regression Model, Least square Estimation. Tests and confidence Intervals, Model Adequacy checking, Problems of Multicollinearity, Ridge Regression, Principal component Regression.

References

1. *Applied Multivariate Methods for Data Analysis*, Johnson D.E., Duxbury Press (1998).

2. *Multivariate Data Analysis* (Fifth Edition), Hair, J.F. Jr., Anderson, R.E., Tatham, R.L. and Black, W.C., Pearson Education, 2006.

3. *Applied Multivariate Techniques*, Sharma S., Wiley, 1996.

4. *Multivariate Statistical Process Control with Industrial Applications*, Mason, R.L. and Young, J.C., ASA–SIAM Series in Statistics and Applied Probability, 2001.

5. *Marketing Research* (Fifth Edition), Malhotra, N., Prentice Hall, 2006.

2.3 Second Semester Elective Courses

Game Theory

1. Introduction (8)

   Introduction to Game theory and its applications Examples of different kind of games.

2. Non-cooperative game (16)

   Two-person zero-sum game, Solution approach by graphical method and LP method.

   Bimatrix game, Concept of Nash equilibrium and its computation using Lemke-Howson algorithm.

3. Introduction to stochastic game with examples (16)

   Classes of two-person zero-sum structured stochastic games.

4. Cooperative games (15)

   Introduction to Cooperative games. Solution concepts such as core, Shapley value, nucleolus etc.

References

1. *Game Theory*, Guillermo Owen, Academic Press.

2. *Game Theory for Economists*, Jurgen Eichberger, Academic Press.

3. *Competitive Markov Decision Processes*, Filar, J.A. and Vrieze, O.J., Springer, New York, 1997.

Capability Maturity Models

1. Introduction to Qu8ality and Process Standards (2)

   What is Quality? How do you achieve quality? Role of process frameworks in achieving quality. Overview of different process standards in different areas

2. ISO 9001:2008 (10)

   Introduction to ISO. Evolution of ISO 9001:2008. Clause of ISO 9001:2008. Application of ISO 9001:2008. Audit

3. Introduction to CMMi (3)

Role of software Engineering Institute in formulation Capability Maturity Model, Evolution of CMM and CMMI, Benefits of CMMI. Application of CMMi to Software and Systems. CMMi Model Representations. Process Areas in CMMi. Equivalence of two representations. Utility of the representations.

4. CMMi Staged Representation –details of practices in Levels 2,3,4,5 (15)

   Process areas in different levels and use in SS, IPPD, Generic Goals and Specific Goals and Generic Practices and Specific Practices in 25 Process Areas. PA Diagram and Symbols used.

5. Implementing the practices in different levels (5)

   Techniques used to implement the practices at all levels

6. Synergy between ISO 90001:2008 and CMMi (5)

   Terminology translation, mapping between ISO 9001:2008 and CMMi, ISO 9001:2008-CMMI relationships, Synergy between ISO 9001:2008 Clauses and Process Areas, ISO 9001 requirements no covered by CMMi.

7. Introduction to ISO 15504 (SPICE) (4)

   Structure of ISO 15504, Relationship to other standard, Capability Levels, Process Attribute in different Levels, Attribute Ratings, Process Assessment

8. Synergy between CMMi and Spice (5)

   Comparison of SPICE and CMMi, similarities between CMMi – representation.

9. Migration to Six Sigma (6)

   From ISO 9001:2008, CMMi to Six Sigma, Similarities between CMMi Process Areas, and ISO 9001:2008 Clauses and Techniques in Six Sigma, Tools used in DMAIC.

References

1. *ISO 9001 Quality Management Systems-Requirements*, International Organization for Standardization, Reference Number ISO 9001:2000€.

2. *CMMI Distilled*, D.M. Ahern, A. Clouse, R. Turner, Pearson Education, 2004.

3. *The Six Sigma Way*, P.S. Pande, R.P. Neuman, R.R. Cavanagh, McGraw Hill Publication, 2000.

4. Improving IT effectiveness through software process assessment, M. Craigmyle and I. Flecther, *Software Quality Journal*, Vol. 2, pp. 257-264 (1993).

5. *Managing the Software Process*, W.S. Humphery, Addison Wesley, 1989.

6. Capability Maturity Model, Version 1.1, M.C. Paulk, B. Curtis, M.B. Chrissis and C.V. Weber, *IEEE Software*, Vol.10, No. 4 July 1993, p. 18-27.

7. *Information Technology Process Assessment*, ISO/IEC 15504-1:2004.

Marketing Research

1. The marketing information system-general MIS dimensions – role of marketing research (6)

2. Securing Marketing information for decision making (36)

   (a) Securing internal sales and cost information.

   (b) Securing information from respondent-types of information, communication methods, collection methods, Questionnaire design and formulation, Sample design and validation, Tackling non response, Dias, unwilling to respond, detection of inaccuracies and ambiguity.

   (c) Securing and using psychological information-attitude, trade and motivation.

   (d) Securing unanticipated and commercial information – Panel information, Stores audits, Field information, independent sample survey-design and analysis.

   (e) Advertising research.

3. Analytical methods (13)

   (a) Measuring and using potential, Segmentation.

   (b) Forecasting as applicable to marketing-use of moving average, exponential smoothing-Box and Jenkins method.

   (c) Conjoint analysis.

   (d) Introduction to Stochastic models of buying behaviour-Brand Choice and purchase incidence modelling – Brand share prediction – Parfitt and Collins model, other models.

References

1. *Marketing Research, Information Systems and Decision Making*, Kenneth P. Uhl and Bertram Schoner, John Willey and Sons, 1969.

2. *A Practical Guide Book to Market Research*, D.M. Sarwate, Everest, Pune, 1998.

3. *Marketing Research*, G.C. Bery, Tata-McGraw Hill, 2008.

4. *Research for Marketing Decisions*, Paul Green, Donald Tull and Gerald Albaurn, Prentice-hall Of India, 2008.

5. *Stochastic Models of Buying Behaviour*, W.F. Massey, D.V. Montgomery and D.G. Morrison, The MIT Press, 1969.

Data Base Management

1. Basic concept (4)

   Introductory database terminologis, data models, advantages of DBMS, Datatypes in programing languages vs database, identifying entities and relationships, hierarchical, network, relational and object oriented databases, hybrid models.

2. The relational model (10)

   Relational schema, tuples, domains, advantages of relational model, primary composite and foreign keys relational algebra, relational calculus, views, integrity constraints, types and integrity maintenance, well structured relations: insertion, deletion and modification anomalies, physical database design and performance.

3. The SQL language (12)

   SQL relational database language (DDL, DML, SELECT-FROM-WHERE, groping aggregation, subqueries), database definition: CREATE TABLE, ALTER TABLE, CREATE VIEW, database manipulation: SELECT, INSERT, UPDATE and DELETE statements, SQL expressions and functions, comparison and boolean operators, ORDER by, GROUP BY and HAVING clauses, table joins, simple and complex joins, outer joins and NULL values, sub-quires, nested quires, SQL execution models, recursion in SQL 3, embedded SQL, Query by Example, query optimisation, application development using JDBC, application development using PL/SQL, query optimization, concurrency control, query execution plans, triggers and stored procedures.

4. Database design (8)

   ER modelling, database normalization, first second and third normal forms, Boys-Codd normal form, extension of normal forms, ER and EER mapping.

5. Transaction Management (6)

   Transaction processing, desirable properties of transaction, need for concurrency control, schedule and recoverability, serializability, types of locks, levels of locking (data and records), two phases locking, recovery techniques.

6. Database Indexing (4)

   B-trees has-based indexing creating indexes, index manipulations (create, update, drop), bitmap indexing.

7. Current trends (8)

   Object databases and XML, client-server architecture, distributed databases, parallel databases, temporal databases, object- relational databases, VLDB, replication and partitioning, Internet and Intranet databases, Datawarehouses, Database languages, object oriented query languages.

8. Case studies (4)

References

1. *Introduction to Database Systems*, C.J. Date, Narosa Publishers.

2. *Database System Concepts* (5th Edision), Henry F. Korth, Abraham Selberschatz and S.Sudarshan, McGraw Hill.

3. *Prenciples of Database Systems*, J. Ullman, Galgotia Publishers.

Software required

Oracle 10g, Microsoft SQL software, MS-Access.

Pattern Recognition

1. Elements of Image processing and Analysis (15)

   Biology and physics of image formation and recognition-Digital images.

   (a) Components of image processing system—sensors, digitizer, processers, display unit, and hard copier.

   (b) Mathematical preliminaries required—vector algebra, orthogonal transformations, probability and statistics, fuzzy sets and properties, and mathematical morphology.

(c) Image processing—Greyvalue histograms, Greyvalue distributions and statistics, thresholding and segmentation; Point operations—Histogram transforms, pixels, gridding and quantization; Patterns and classes; image enhancement, image smoothening, image sharpening, image restoration, image compression, and image registration.

(d) Image analysis—image segmentation, edge and line detection, feature extraction, and description.

(e) Recognition—deterministic approaches, statistical approaches, fuzzy mathematical approach, syntactic approach, and morphological approaches.

2. Statistical and Fuzzy Mathematical Approach-Pattern Recognition (15)

   Bayesian decision theory; Maximum likelihood and parameter estimation; Nonparametric techniques; Qualifying structure in pattern description and recognition; Grammar based approach; Neural pattern recognition.

3. Structural and Syntactic Pattern Recognition (24)

   (a) Segmentation (9)

   Detection of discontinuities – Piont, Line, Edge and Combined detection; Edge linking and boundary detection—Local processing, Global processing via Hough transform and Graph Theoretic techniques; Thresholding—Foundation, The role of illumination, Simple Global Thresholding, Optimal Thersholding, Thershold selection based on boundary characteristics, thresholds based on several variables; Region-Oriented segmentation—Basic formulation, region growing by pixel aggregation, region splitting and merging, morphologic segmentation, watersheds; The use of Motion in Segmentation—spatial and frequency domain techniques; Texture segmentation—pattern spectra and Granulometries.

   (b) Boundary and Region Representation and Description (15)

   Representation and Description: Representation schemes—chain codes, polygonal approximations, signatures, boundary segments, the skeleton of a region; Boundary descriptors—Simple descriptors, shape numbers, Fourier descriptors, moments; Regional descriptors—simple descriptors, topological descriptors, texture, moments; Morphology—Dilation, erosion, opening, closing, Hit-or-Mist Transform, basic morphological algorithms, extensions to gray-scale images; Relational Descriptors.

   Recognition and Interpretation: Decision Theoretic Methods—Matching (Minimum distance classifier, Matching by correlation); Optimum statistical clas-

sifier (Foundation, Bayes classifier for Gaussian pattern classes); Neural networks (Background, perceptron for two pattern classes, training algorithms, multiplayer feedforward neural networks).

Structural methods: match shape numbers, string matching, syntactic methods.

Interpretation: Object measurements—Size, shape and orientation: Statistics of size distributions, resolution and scale; shape analysis, orientational statistics; Stereological models and microstructural analysis; Analysis of 3-D data sets.

References

1. *Pattern Classification* (2nd Ed), R.O.Duda, P.E. Hart and D.G. Stork, John Wiley & Sons, NY, 2001.

2. *Structural Pattern Recognition*, T. Pavlidis, Springer-Verlag, NY, 1977.

3. *Image analysis and Mathematical Morphology*, J. Serra, Academic Press, 1982.

4. *Digital Image Processing*, R.C. Gonzalez and R.E. Woods, Addison-Wesley Publishing Company, 1992.

5. *Digital Image Processing and Analysis*, B. Chanda and D. Dutta Majumdar, Prentice Hall, India.

6. *Fuzzy Mathematical Approaches to Pattern Recognition*, S.K. Pal, and D. Dutta Majumdar, John Wiley & Sons, NY.

Neural Networks

1. Introduction to Soft Computing and ANN (8)

   An overview of analysis and Design of intelligent systems using soft computing techniques, Basic Concepts of Artificial Neural Network (ANN), Similarity with biological neurons, General characteristics, Historical development and domain specific applications, Statistical modeling and ANN.

2. Building blocks of ANN and Fundamental ANN Models (7)

   (a) Architecture, Weights, Bias, Net Input, Threshold, Activation functions, Training and its related parameters, Simulation.

   (b) McCulloch-Pitts and Hebb Nets: architecture and algorithms with examples.

3. Learning Rules of ANN (6)

   Hebbian, Perceptron, Delta, Competitive, Perceptron convergence theorem.

4. Typical Networks (6)

   (a) Single Layer Perceptron – architecture, training and application algorithm

   (b) Adaline and Madaline - architecture, training and application algorithm

   (c) Discrete Hopfield Net - architecture, training and application algorithm.

5. Feed Forward Networks (7)

   (a) Multi Layer Perceptron (MLP) – Generalized Delta (Back Propagation) Learning rule, architecture, training algorithm, selection of parameters, learning constraints, application algorithm, local optimum, merits and demerits, applications.

   (b) Radial Basis Function (RBF) – architecture, training algorithm.

6. Self Organizing Map (4)

   (a) Kohonen Self Organizing Feature Maps (SOM) – architecture, training algorithm.

   (b) Learning Vector Quantization (LVQ) – architecture, training algorithm.

7. Some Special Purpose Networks (5)

   (a) Ensemble networks – purpose and concepts.

   (b) Adaptive Resonance Theory (ART) - architecture, training algorithm, ART 1, ART 2.

   (c) Probabilistic Neural Network (PNN) - architecture, training algorithm.

   (d) Modular Networks.

8. Case Studies (6)

9. Use of Software (6)

   Developing ANN models with the help of computer software such as MATLAB, STATISTICA, NEUROMAT etc. for solving real-life problems and related performance measures with graphical interface.

References

1. *An Introduction to Neural Networks*, K. Gurney, UCL Press.
2. *Computational Intelligence*, Andries P. Engelbrecht, John Wiley & Sons, 2003.
3. *Neural Networks, Fuzzy Logic and Genetic Algorithms*, S. Rajasekaran and G.A.V. Pai, PHI.
4. *Neural Network Fundamentals*, N.K. Bose, P. Liung, McGraw Hill, 1996.
5. *Neural Networks*, Haykin Simon, Macmilan, UK, 1994.
6. *Neural Networks for Pattern Recognition*, C. Bishop, Oxford University Press, 1995.
7. *Neural Networks for Statistical Modeling*, Murray Smith.
8. *Neuro-Fuzzy PR-Methods in Soft Computing*, Sankar K.Pal and Sushmita Mitra, John Wiley & Sons.

Trouble Shooting and Problem Solving for Quality Improvement

1. Definition of QC problems (2)
2. Problem solving approach from QC viewpoint (6)

   Mindset, quality first, consumer orientation,
3. PDCA cycle (2 hours),
4. Priority consciousness and management by facts (5)
5. Process control, dispersion control, recurrence prevention, standardization (10)
6. Benefits of QC problem solving approach (2)
7. QC seven step formula (10) Selecting topics, understanding situation and setting targets, planning activities, analyzing causes, considering and implementing counter-measures. checking results, standardizing and establishing control.
8. Major SQC tools and techniques (6)
9. Case studies (8)
10. Outline of Software Packages available (4)

References

1. Process Quality Control: Trouble shooting and Interpretation of Data, (2005): By Ellis R. Ott, Edward G. Schilling, Dean V. Neubauer, Edward G. Schilling, 4 th Edition, ASQ Quality Press.

2. Trouble Shooting Manufacturing Processes, (1988): By Soc. of Manufacturing Engineers (SME), Michigan, USA.

3. Statistical Methods For Quality Improvement, (1987): By Hitoshi Kume. Productivity Press, 1987.

4. *Statistical Methods for Quality Improvement*, Thomas P. Ryan, John Wiley & Sons, 2000.

5. *Quantitative Methods for Quality and Productivity Improvement*, Robert F. Hart and Marily K. Hart, ASQ Quality Press, 1989.

6. *Tools and Methods for the Improvement of Quality*: By Gitlow, Gitlow, Oppenheim and Oppenheim, Richard D. Irwin Inc., 1989.

Measuring Customer Satisfaction

1. Introduction (3)

   Customer satisfaction-concept, satisfaction as expectations, satisfaction as affective reaction parameters/dimensions of satisfaction.

2. Measurement of customer satisfaction dimensions. (3)

   Confirmation/disconfirmation paradigm, customer satisfaction measurement models and indices.

3. Customer (6)

   Customer frame, customer segments, rationale of segmentation, methods of segmentation, customer segments vs. customer satisfaction dimensions.

4. Customer satisfaction survey (8)

   Planning for survey, types of survey, survey questionnaire construction item generation response, formal, item selection, determining questions or, items, satisfaction items revisited, characteristics of good items, response formats, checklist formats, Likert-type formats and its advantages.

5. Examples of CSM (2)

   Questionnaires for manufacturing industries (automobile electronics and electrical appliances, consumer durables, food items, entertainment etc.), IT industry, Support services etc.

6. Sampling methods for survey (8)

   Types of sampling-census/judgmental/statistical sampling, sample size and sampling error, random selection procedure, response rates

7. Analysis of survey data (9)

   Standard error of measurements, sources of errors and reliability estimates, measures of equivalence and parallel forms reliability, measures of stability and test-retest reliability, internal consistency, split-half reliability estimates, factors affecting reliability, inter-judge agreements-Cohens kappa index, Cronback's Alpha estimates, Krippendorff s Alpha-Reliability.

8. Analysis of categorical data (10)

   Statistical techniques for analyzing categorical data with particular emphasis on categorical factor analysis and polychoric principal component analysis, other statistical techniques for analyzing categorical data.

9. Managing customer dissatisfaction and customer relations. (3)

10. Customer satisfaction and Customer loyalty. (3)

References

1. *Measuring Customer Satisfaction and Loyalty: Survey Design, Use and Statistical Analysis Methods* (3rd Edition), Bob E. Hayes, ASQ Publication, USA, 2008.

2. *Measuring Customer Satisfaction – A Guide to Managing Quality Customer Service*, R.F. Gerson, Viva Books Pvt. Ltd., 2004.

3. *Handbook of Customer Satisfaction*, N. Hill and J. Alexander, Infinity Books, New Delhi, 2004.

4. *Measuring Customer Satisfaction: Hot Buttons, Other Measurement Issues*, J.H. Myers, South Western Educational Publishing, 2000.

5. *Customer Satisfaction Measurement and Management – Using the Voice of Customers*, Naumann Giel, South-Western Thomson Learning, 1995.

6. *Categorical Data Analysis* (2nd edition), Alan Agresti, Wiley Interscience, 2002.

7. *Categorical Data Analysis Using SAS* (2nd edition), M.E. Strokes, C.S. Davis and G.G. Koch, SAS Institute & Wiley, 2003.

Software Reliability

1. Introduction to Software Reliability (2)

   Definition of software reliability, its importance in present day scenarios, speciality of a software product, sources of uncertainty in a software product, comparison between software and hardware reliability.

2. Software reliability and other associated problems (8)

   Development of the software reliability problem, the problem of optimum software release time, some basic mathematics on differential calculus and optimization methods.

3. Software reliability models (12)

   Jelinski—Moranda (JM) model, extensions of the JM model, discussion on the JM model assumptions, some very useful models with assumptions, some recent developments.

4. Parameter Estimation (10)

   Methods of estimating the parameters for the above models, actual implementations of the models with data using either available software packages or by writing programs.

5. Software reliability for web-based software (4)

   Problems in Web-based software, modeling web-based software reliability problems (some recent models).

6. Software release time models (4)

   Formulation of optimum software release time problem, some important models on software release time problem, parameter estimation, discussion on the models.

7. Case Studies (4)

8. Assignments and exercises (10)

References

1. *Software Reliability -Measurement, Prediction and Applications*, John D. Musa, Anthony lannino and Kazuhira Okumoto, McGraw-Hill, 1987.

2. *Software Reliability*, Hoang Pham, Springer, 2000.

3. *Handbook of Reliability Engineering*, Hoang Pham (ed), Springer, 2001.

4. Measuring and modeling usage and reliability for statistical web testing, Chaitnya Kallepalli and Jeff Tian, *IEEE Transactions on Software Engineering*, Vol.27, No.11, November 2001.

5. Evaluating web software reliability based on workload and failure data, extracted from server logs, Jeff Tian, Sunita Rudraraju and Zhao Li, *IEEE Transactions on Software Engineering*, Vol.30, No.1, 2004.

Human Factors in Continuous Improvement

1. Human side of continuous improvement. (5)

2. Human Factors and Systems (8)

   Various facets of human-organisation, human-technology and human-machine interaction.

3. Measurement (12)

   Assessing and measuring relevant human characteristics such as, behavior, skill, abilities, limitations for designing objects, facilities, workplace, environments, work methods and other systems associated with every business activity.

4. Optimization (10)

   Optimizing the relationships between human and organisation, human and technology, human and machine etc. with respect to business goals and objectives.

5. Training and other motivational measures for aligning human factors with continuous improvement. (10)

6. Group activity (10)

   Group processes, design and realization of effective group processes, synergising group activities/processes with business values and business goals.

References

1. *Human Factors, Business Excellence and Corporate Sustainability: Differing Perspectives, Joint Objectives*, Klaus J. Zink, Ulrich Steimle and Klaus Fischer, Physica-Verlag HD, 2008.

2. *Human Factors Methods For Improving Performances in Process Industry*, C. Devlin and D.A. Crowl, Wiley, 2007.

3. *The Continuous Improvement Process- Strengthen The Organizational Citizenship Behaviour in Manufacturing Companies - A Consulting Approach*, Peter Bebersdorf, VDM Verlag, 2007.

4. *Emerging Needs and Opportunities For Human Factors Research*, Raymond S. Nickerson (Editor), National academy Press, Washington, D.C. 1995.

5. *Human Factors and Comprehensive Management Concepts: A Need for Integration Based on Corporate Sustainability*, Klaus J. Zink, Physica-Verlag HD, 2008.

Markov Analysis and Modelling

1. Introduction (8)

   Stochastic Processes – first order stationery, second order stationery, orderly stochastic processes, time in stochastic processes.

2. Random walk model, Birth-death processes (4)

3. Markov property, strong Markov properties, Markov Process (4)

4. Markov Chain (20)

   Transition probabilities discrete time Markov Chain, digraph representation— definition and basic properties, class structure, first passage time, classification of state – transient – recurrent/irreducible/aperiodic/irregular/ergodic Markov Chain, Finite Markov Chain.

5. Rate of convergence to stationarity (3)

6. Continuous time Markov Chain (9)

   Continuous time random processes, some properties of Exponential distribution, Poisson process.

7. Example of Markov Chain Application (7)

   Brand Selection problem, inventory management etc. with use of software.

References

1. *Stochastic Processes*, J.L. Doob, John Wiley, 1990.

2. *Probability, Random Variables, and Stochastic Processes*, A. Papoulis, McGraw Hill, 1984.

3. *Markov Processes Vol I and II*, E.B. Dynkin, Springer Verlag, Berlin, 1965.

4. *Finite Markov Chains*, J.G. Kemeny and J.L. Snell, Springer Verlag, New York, 1976.

5. *Elements of the theory of Markov Processes and their Applications*, A.T. Barucha-Reid, McGraw Hill, London, 1960.

6. *Introduction to Finite Markov Processes*, S.R. Adke and S.M. Manjunath, Wiley Eastern, Calcutta, 1984.

2.4 Third Semester Compulsory Courses

Applied Regression Analysis

1. Simple linear Regression (5)

   The simple regression model, Importance of scatterplot, Least squares method of estimation of parameters, Test for slope and intercept, Interval estimation in simple regression, Prediction of new observations, Co-efficient of determination, Estimation by maximum likelihood method

2. Checking Model Adequacy (5)

   Residual analysis, Detection and treatment of outliers, Lack of fit and pure error, Need for transformation, Weighted least squares.

3. Multiple Linear Regression (22)

   Multiple regression models, Estimation of model parameters, Confidence intervals and hypothesis testing in multiple regression, Prediction of new observations, Multiple correlation co-efficient. Polynomial regression.

   Checking for the validity of model assumptions: Role of residuals and hat matrix, standardized and studentized residuals. Plots – Fitted values against residuals, regressors against residuals, added variable plots, normal probability plot.

   Detecting influential observations: DFBETAS, DFFITS, Cook's D, COVRATIO.

Sources and effects of multi-co linearity, multicolinearity diagnostics – VIF and variance proportions.

Methods for dealing with multicollinearity, Principal component regression and its pitfalls, Subset selection -Criteria for choice of subset size, Co-efficient of multiple determination, Residual mean square, Adjusted co-efficient of determination, Mallows' Cp statistic. AIC and BIC criteria. Comparison of different criteria. Ridge regression.

4. Indicator Variables (6)

   Concept and use of indicator variables as regressors, models with only indicator variables, interaction teams involving indicator variables, indicator variables for segmented models.

5. Topics in the Use of Regression analysis (8)

   Heteroscadasticity, Transformations, Box-Cox transformation, Autocorrelation, Generalized least squares, Designed experiments for regression, Relationship between regression and analysis of variance, validation of Regression models. Non-linear models – Estimation of parameters of a non-linear system.

6. Logistic Regression (10)

   Discrete response models. Linear probability models. Logistic regression model, Test of significance of coefficients, Multiple logistic regression model, Fitting and testing the significance of the model, Interpretation of the coefficients of the logistic regression model – Dichotomous, Polytomous and Continuous independent variable, Measures of goodness of fit – Pearson Chi-square and Deviance, Hosmer – Lameshow tests, Logistic regression diagnostics. Probit regression.

For all the topics above: Examples and Exercises with use of software packages like Minitab / JMP/ SPSS/ Statistica/ Systat/excel etc.

References

1. *Applied Regression Analysis* (3rd Edition), Norman R. Draper and Harry Smith, Wiley Series in Probability & Statistics, John Wiley, 1998.

2. *Applied Regression Analysis* (2nd edition), John O. Rawlings, Sastry G. Pantula and David A. Dickey, Springer 2001.

3. *Introduction to Linear Regression Analysis*, D.C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining : Wiley Series in Probability & Statistics, John Wiley & Sons, 2001.

4. *Regression Analysis by Example*, Samprit Chatterjee, Betram Price, Ali S. Hadi, Wiley Series in Probability & Statistics, John Wiley & Sons, 2000.

5. *An Introduction to Generalized Linear Models*, Annette. J. Deobson, Texts in Statistical Science, Chapman & Hall/CRC, 2002.

6. *Applied Logistic Regression*, David W. Hosmer and Stanley Lemeshow, John Wiley & Sons, 2000.

Non-linear Programming

1. Non-Linear Programming (30)

   Introduction and illustrative examples; convex sets and functions and their generalizations; unconstrained optimization problem and the optimality conditions; the constrained nonlinear optimization problem; Karush-Kuhn-Tucker optimality conditions; necessary and sufficient conditions for optimality; brief introduction to the linear complementarity problem, quadratic, separable, fractional and geometric programming problems.

2. Supply Chain Management (15)

   Introduction; Managing inventories in the supply chain; Managing transport in the supply chain; Managing locations in the supply chain; Managing days in the supply chain.

3. Case Studies (15)

   Presentation of some selected case studies from the following areas: Production systems, Energy systems, Airline Optimization, Financial Engineering, E-Commerce, Water resources and Military applications.

References

1. *Operations Research and Management Science, Hand Book*, A. Ravi Ravindran (editor), CRC Press, Taylor & Francis.

2. *Nonlinear Programming – Theory and Algorithms* (second edition), Mokhtar S. Basaraa, Hanif D. Sherali and C.M. Shetty, John Wiley & Sons Inc., New Delhi.

3. *Network Programming*, Katta Murty, Prentice Hall.

4. *Handbook of Applied Optimization*, Panos M. Pardalos and Mauricio G.C. Resende (editors), Oxford University Press.

5. *The Linear Complementarity Problem*, Cottle, Pang and Stone, Academic Press.

Industrial Experimentation

1. Introduction: (2)

   (a) What is experimentation? Why Experimentation? Role of experimental designs in industries.

   (b) List of Design terminologies.

   (c) Experimental process from the point of view of a statistician, Concept of and components of Experimental Error. Identification and classification of factors.

   (d) Historical overview

      i. Classical statistical design of experiments (R.A. Fisher to G.E.P BOX),

      ii. Quality Era: (Taguchi Method phase I, II, III),

      iii. Post Taguchi developments in Classical statistical design of experiments,

      iv. Current trends, e.g., Computer experiments.

   (e) Steps in a statistical design of experimental project.

   (f) Basic principles.

2. Block Designs: (5)

   (a) Competently Randomized Design

   (b) Concept of blocking

   (c) Paired comparisons as block design

   (d) Randomized complete block design

   (e) Latin square design

   (f) Residual analysis: assessment of model, problems; use of Statistical software.

3. Classical Factorial Designs (8):

   (a) 2^k and 3^k factorial designs, Statistical Analysis, Model adequacy checking.

   (b) Fundamental principles regarding factorial effects (Sparsity, heredity, hierarchy principles). Analysis of a single replicates, use of normal and half normal plots.

   (c) Confounding 2^k in two blocks, four blocks and in 2^p blocks, 3^k in 3, 9 and 3^p blocks.

   (d) 2^{k-p} and 3^{k-p} Fractional Factorial designs, (Criteria for design selection: Concept of Design Resolution and Minimum Aberration Designs).

(e) Residual analysis: assessment of Model, Problems. Use of Statistical software.

4. Nested/Hierarchical Designs: (4)

   Two stage nested design, -Statistical analysis, estimation of model parameters, diagnostic checking. General m-stage nested designs. Design with nested and crossed factors.

5. Designs with randomization restriction: Split plot, split unit designs (2)

6. Response Surface Methodology (7):

   Introduction, Method of steepest ascent, Analysis of quadratic models, Response surface designs for first order and second order models, rotatable and orthogonal designs – Equiradial, simplex, central composite, Box Behnken designs, Problems.

7. Mixture Designs (7) Introduction, Simplex lattice designs (Scheffe). Simplex centroid designs, Extreme vertices designs, Response surface designs with mixtures-first order and second order model for constrained mixture spaces, Problems.

8. Taguchi Methods (Phase I): Orthogonal Arrays (6)

   Linear graphs and their applications, Different types of Orthogonal Arrays, Split unit design, Multilevel arrangement, Pseudo-factor designs, Statistical analysis, Problems.

9. Taguchi's Robust Designs (Phases II and III) (6)

   Taguchi's philosophy of quality engineering, Loss function, Taguchi's Noise strategy contrasting Basic principles of classical experimentation. Three steps approach to robust design, Parameter designs, Inner array and outer array, Signal to noise ratios static and dynamic, Tolerance designs, Statistical analysis, Problems.

10. Post Taguchi development in classical statistical design (6)

    Critique of Taguchi Methods

11. Computer Experiments, Space Filling Designs (2): Introduction, etc.

References

1. *Design and Analysis of Experiments*, D.C. Montgomery, Wiley, NY.

2. *Statistics for Experimenter - An Introduction to Data Analysis and Model Building*, G.E.P. Box and W.G. Hunter, Wiley, N.Y.

3. *Design of Experiments – A No-Name Approach*, T.J. Lorenzer and V.L. Anderson, Marcel Dekker, NY.

4. *Experimental Designs*, W.G. Cochran and G.M. Cox, Wiley, NY.

5. *Design of Experiments – A Realistic Approach*, V.L. Anderson and R.A. McElean, Marcel Dekker, NY.

6. *Statistical Design and Analysis of Experiments*, P.W.M. John, MacMillan.

7. *The Design of Experiments*, R.A. Fisher, Hafner NY.

8. *Statistical Design and Analysis of Industrial Experiments*, S. Ghosh, Marcel Dekker, NY.

9. *Design and Analysis of Experiments*, M.N. Das and N.C. Giri, Wiley Eastern, Delhi.

10. *Empirical Model Building and Response Surface*, G.E.P. Box and N.R Draper, Wiley, NY.

11. *Response Surface Methodology - Process and Product Optimisation Using Designed Experiments*, R.H. Myers and D.C. Montgomery.

12. *Response Surface Designs and Analysis*, A.I. Khuri and J.A. Cornel, Marcel Dekker, NY.

13. *Introduction to Quality Engineering*, G. Taguchi, APO, UNIPUB, White Plains, NY.

14. *Introduction to Off-line Quality Control*, G. Taguchi, Central Japan Quality Control Association, Nagoya, Japan.

15. *System of Experimental Designs - Engineering Methods to Optimise Quality and Minimise Cost*, UNIPUB/Kraus International, White Plains, NY.

16. *Experiments with Mixtures – Design, Model and the Analysis of Mixture Data*, J.A. Cornell, Wiley, NY.

17. *Experiments, Planning, Analysis and Parameter Design Optimization*, C.F. Jeff Wu and Michael Hamada, John Wiley & Sons, New York, 2000.

Six Sigma – Business Excellence Strategy and Problem Solving Framework

1. Introduction to Six Sigma with key concepts (3)
2. Principles of Six Sigma, DMAIC Philosophy (3)
3. Overview of Six Sigma tools and techniques (16)

   Balance Score Cards, Quality Function Deployment (QFD), SPC tools, DOE, Regression, Multivariate Analysis etc.
4. Six Sigma Management Models (4)
5. Six Sigma Organisation (4)

   Executive leader, champion/sponsor, master black belts, black belts, green belts, yellow belts and professional of such competent levels.
6. Lean Six Sigma (6)
7. DFSS, Innovation Vs. DFSS (8)
8. Six Sigma Implementation (5)

   Leadership and people management, teamwork, systems and process management including benchmarking and self-assessment.
9. EFQM Business Excellence Models (6)

   Components of business excellence models, Six sigma as route to Business Excellence.

References

1. *Six Sigma For Business Excellence*, Penelope Przekop, McGraw-Hill, 2005.
2. *Design For Six Sigma*, Greg Brue, Robert Launsby, McGraw-Hill, 2003.
3. *What Is Design For Six Sigma*, Roland Cavanagh, Robert Neuman and Peter Pande, Tata-McGraw Hill, 2005.
4. *The Six Sigma Way: How GE, Motorola, And Other Top Companies Are Honing Their Performance*, Peter S. Pande, Robert P. Neuman, Roland R. Cavanagh, McGraw-Hill, 2000.
5. *What Is Lean Six Sigma*, Mike George, Dave Rowlands and Bill Kastle, McGraw-Hill, 2004.

6. *Six Sigma Business Scorecard*, Praveen Gupta, McGraw-Hill, 2004.

7. *Six Sigma Deployment*, Cary W. Adams, Charles E. Wilson Jr. and Praveen Gupta, Elsevier Science, 2003.

2.5 Third Semester Elective Courses

Quality Audit

1. Introduction to Quality audit (6) Quality management principles; Role of audit for quality assurance and Quality management; Terms and vocabulary ISO 9000-2005.

2. System audits (20)

   Audit types- Compliance and adequacy audits- Internal and external audits; Auditors qualifications; Audit cycle - Audit planning- Audit steps- reporting-actions - Follow ups; Guidelines for quality and/or environmental systems, auditing ISO 19011: 2002; QMS and EMS audits for ISO 9001-2008 and ISO 14000-2004.

3. Sector specific audits (16)

   Auditing for compliance to TL 9000 telecommunications specific requirements and TS16949 automotive specific requirements; Audit for IT and IT enabled system, Introduction to CMM auditing, BPO/Call Center Performance Audit- COPC-2000 standard.

4. Safety audits (6)

   Scope and purpose, Conducting safety audits; safety audit check lists; Safety audits for OHSAS 18001:2007.

5. Introduction to Product auditing (7)

   Scope and purpose; Stages of evaluation Designing the audit plan- sampling- Action on discrepancies, Product audits manual, product auditors, CE marking.

References

1. *The Quality Audit Handbook*, ASQ Quality Audit Division, ASQ Quality Press, Milwaukee, Wisconsin.

2. *The Quality Audit: A Management Evaluation Tool*, Charles A. Mills, ASQC Publication.

3. *Internal Quality Auditing: Meeting the Challenge of ISO 9000:2000*, William A. Stimson, Paton Press, 2001.

4. *Internal Quality Auditing*, Denis Pronovost, ASQ Publication, ASQ Quality Press.

5. *ISO 9001:2008 Small Changes – Big Opportunities*, Nigel H. Croft, ebook.

6. Measuring effectiveness and suitability of a quality system, A.K. Chaudhuri and U.H. Acharya, *Total Quality Management* (UK), March 2000, Vol 11, No 2, pp. 149-153.

Supply Chain Management

1. Introduction (6)

   Understanding the Supply Chain, Supply chain networks, Integrated supply chain planning, process view (mapping and flow chart) of a supply chain, supply chain flows, Overview of supply chain models and modeling systems, Supply chain planning: Strategic, operational and tactical.

2. Management Philosophy (4)

   Supply Chain Management as a Management Philosophy, Function of Supply Chain Management, Customer focus in Supply Chain Management, Buyers and Suppliers Perspective, Value chain.

3. Strategies and Performance (8)

   Supply chain strategies, Supply chain performance achieving strategic fit through different steps, Obstacles to achieving Strategic Fit, value chain. Supply chain performance measurement: Supply chain drivers, Metrics and obstacles, The balanced score card approach, Performance Metrics.

4. Planning Supply and Demand (6)

   Role of Forecasting in a supply chain, Factors of Demand Forecast, Basic approach to Demand Forecasting, Aggregate planning in supply chain, Managing Predictable variability.

5. Planning and Managing Inventories (10)

   Introduction to Supply Chain Inventory Management - cycle and safety inventory.

   Inventory theory models: Economic Order Quantity Models, Reorder Point Models and Multiechelon Inventory Systems, Relevant deterministic and stochastic inventory models.

6. Distribution Management (9)

   Role of transportation in a supply chain - direct shipment, warehousing, cross-docking; push vs. pull systems; transportation decisions (mode selection, fleet size), Facilities decisions in a supply chain, Supply chain facility layout and capacity planning, Designing Distribution Networks and Applications to e-Business, Information Technology in a Supply Chain.

7. Strategic Cost Management (6)

   The financial impacts, Pricing and Revenue Management in the Supply Chain, Volume leveraging and cross docking, target pricing, Measuring service levels in supply chains, Customer Satisfaction / Value / Profitability.

8. Case Studies and Use of software packages like CPLEX (6)

References

1. *Supply Chain Management* (3rd edition), Sunil Chopra, Peter Meindl and D.V. Kalra, Pearson Education, 2007.

2. *Supply Chain Management: Strategy, Planning and Operation* (2nd edition), Sunil Chopra and Peter Meindel, Pearson Education, 2004.

3. *Logistics and Supply Chain Management: Cases and Concepts*, G. Raghuram and N. Rangaraj, Macmillan, New Delhi, 2000.

4. *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies* (2nd edition), D. Simchi-Levi, P. Kaminski and E. Simchi-Levi, Irwin, McGraw-Hill, 2003.

5. *Modelling the Supply Chain*, J. Shapiro, Duxbury Thomson Learning, 2001.

6. *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies* (Second Edition), David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi, McGraw-Hill/Irwin, New York, 2003.

7. *Introduction to Supply Chain Management*, Robert Handfield and Ernest Nichols, Prentice Hall, 1999.

8. *Supply Chain Management*, John T Menzer, Response Books (Sage Publishers), 2001.

9. *The Management of Business Logistics: A Supply Chain Perspective* (7th Edition), John J. Coyle, Edward J. Bardi and C. John Langley Jr., Thomson Asia.

10. *Business Logistics/Supply Chain Management* (fifth edition), Ronald H. Ballou, Pearson Education, India, 2003.

11. *Essentials of Supply Chain Management*, R.P. Mohanty and S.G. Deshmukh, Jaico Publishing House.

3 Dissertation

The dissertation has no specific syllabus but consists of all the topics covered till the third semester and such other related topics as deemed necessary by the guide. Normally it is to be completed by the February end, unless the Teachers' Committee/Dean of Studies allows extension of the period.

Two copies of the dissertation are to be submitted to ISI on completion of the work.

4 Project Work

Each student has to do a live project on solving quality/reliability problem in the Industry. The project involves application of the topics covered during Semester – I, Semester – II, Semester – III and such other related topics as deemed necessary by the project supervisor.

It should start on the first working day of March or on a date announced by ISI following the submission of the dissertation and subsequent defense. It should continue for 18 continuous weeks. Normally it is to be completed by the Mid-July, unless the Teachers' Committee / Dean of Studies allows extension of the period.

Two copies of the project report, duly certified by the supervisor, are to be submitted to ISI on completion of the work.