STATISTICS & OPERATIONS RESEARCH SUBJECT AREA

Course units which are available to students admitted for the Statistics and Operations Research course from a separate window by the University Grants Commission (UGC).

SUMMERY OF STATISTICS & OPERATIONS RESEARCH

Course Number	Course Title	No: of credits	Prerequisites	Compulsory courses
ST 101	Introduction to Statistics	3		√
ST 102	Introduction to Probability Theory	3		√
ST 103	Statistics Applications I	1	ST 101 or any other basic statistics course	√
ST 104	Statistics Applications II	1	ST 101 or any other basic statistics course	√
CS 101	Introduction to Computer Science	3		√
CS 102	Programming Techniques	3		√
CS 103	Programming Laboratory I	2	CS 101, CS102	√
MT105	Real Analysis I	3		√
MT 107	Mathematics for Operations Research	3		√
MT 108	Operations Research I	2		√
MT 109	Linear Programming	3	MT 107, MT 108	√
ST 201	Probability Theory	3	ST 102	√
ST 203	Theory of Statistics	3	ST 201	√
ST 204	Sampling Techniques	2	ST 203	
ST 205	Statistical Simulation	2	CS 102, CS 103, ST 203	√
ST 206	Introduction to Data Mining	2	CS 101, ST 101	√
CS 207	Statistical Information Processing	3	CS 101, CS 102	√
CS 208	Programming in Statistical Information Processing	2	CS 207	√
MT 202	Real Analysis II	3	MT 105	
MT 204	Mathematical Methods	3	MT 101	
MT 209	Graph Theory	2		
MT 210	Advanced Linear Programming	3	MT 109	√
MT211	Integer Programming	3	MT 210	√
MT 212	Operations Research II	2	MT 109	√
ST 301	Regression Analysis	3	ST 203	√
ST 302	Statistical Quality control	2	ST 203	√
ST 303	Design and Analysis of Experiments	3	ST 203	
ST 304	Non-parametrics & Categorical Data Analysis	2	ST 203	
ST 305	Multivariate Methods I	2	ST 203	√
ST 306	Data Analysis & Preparation of Reports	1	ST 301, ST 302	√
ST 307	Time Series Analysis	2	ST 203, ST 301	√
ST 308	Bayesian Statistics I	2	ST 203	√
ST325 /MT325	Seminar	1	ST 306, ST307	√
CS 302	Design and Analysis of Algorithms	1	CS 207, CS 208	√
MT 304	Partial Differential Equations	2	MT 103	
MT 313	Convex Analysis	2	MT 202	
MT 314	Network Optimization Theory	3	MT 210	√
MT 315	Operations Research III	2	MT 109, MT 314	√
MT 316	Non-Linear Programming	3	MT 210	√
ST 401	Actuarial Statistics	2	ST 203	√
ST 402	Statistical Data Mining	3	ST 206, ST 305	√
ST 403	Statistics for Bioinformatics	2	CS 207, CS 208	
ST 404	Stochastic Processes	2	ST 201, ST 203	
ST 405	Multivariate Methods II	2	ST 305	√
ST 406	Bayesian Statistics II	2	ST 308	
CS 403	Artificial Neural Networks	3	CS 207, CS 208, CS 302	

CS 405	Fuzzy Logic and Modeling	3	CS 207, CS 208, CS 302	
MT 409	Selected Topics in Applied Operations Research	2	MT 315, MT 316	
MT 410	Optimization for Engineering Design	3	MT 315, MT 316	√
MT 411	Optimization Modeling	2	MT 315, MT 316	√
MT 412	Financial Mathematics	3		√
ST425/MT 425	Project work/Industrial training	3		√

SYLLABI OF STATISTICS AND OPERATIONS RESEARCH

Year One

Semester I	**Semester II**
ST 101 Introduction to Statistics (3 credits)*	ST 102 Introduction to Probability Theory (3 credits)*
ST 103 Statistics Applications I (1 credit) #*	ST 104 Statistics Applications II (1 credit)#*
CS 101 Introduction to Computer Science (3 credits)*	CS 102 Programming Techniques (3 credits)*
CS 103 Programming Laboratory I (1 credit)	CS 103 Programming Laboratory I (1 credit)
MT 107 Mathematics for Operations Research (3 credits)*	MT105 Real Analysis I (3 credits)*
MT 108 Operations Research I (2 credits)*	MT 109 Linear Programming (3 credits) # *

Year Two

Semester I	**Semester II**
ST 201 Probability Theory (3 credits)*	ST 203 Theory of Statistics (3 credits) #*
ST 205 Statistical Simulation (2 credits) #*	ST 204 Sampling Techniques (2 credits) #*
CS 207 Statistical Information Processing (3 credits)*	ST 206 Introduction to Data Mining (2 credits) #
CS 208 Programming in Statistical Information Processing (1 credit)	CS 208 Programming in Statistical Information Processing (1 credit)
MT 202 Real Analysis II (3 credits)	MT211 Integer Programming (3 credits) #*
MT 204 Mathematical Methods (3 credits)	MT 212 Operations Research II (2 credits)*
MT 209 Graph Theory (2 credits)	
MT 210 Advanced Linear Programming (3 credits) # *	

Year Three

Semester I	**Semester II**
ST 301 Regression Analysis (3 credits) #*	ST 303 Design and Analysis of Experiments (3 credits)#*
ST 302 Statistical Quality Control (2 credits) #*	ST 304 Non Parametrics & Categorical Data Analysis (2 credits) #*
ST 305 Multivariate Methods I (2 credits) #*	ST 307 Time Series Analysis (2 credits) #
ST 308 Bayesian Statistics I (2 credits)	ST 325 /MT325 Seminar (1 credit) #*
ST 306 Data Analysis & Preparation of Reports (1 credit) #*	
CS 302 Design and Analysis of Algorithms(1 credit)#	MT 304 Partial Differential Equations (2 credits)
MT 313 Convex Analysis (2 credits)	MT 315 Operations Research III (2 credits)*
MT 314 Network Optimization Theory (3 credits) *	MT 316 Non-Linear Programming (3 credits) *

Year four

Semester I	**Semester II**
ST 401 Actuarial Statistics (2 credits)	ST 404 Stochastic Processes (2 credits)
ST 402 Statistical Data Mining (3 credits) #*	ST 405 Multivariate Methods II (2 credits) #*
ST 403 Statistics for Bioinformatics (2 credits)	ST 406 Bayesian Statistics II (2 credits)
CS 403 Artificial Neural Networks (3 credits)	CS 405 Fuzzy Logic and Modeling (3 credits) #
MT 411 Optimization Modeling (2 credits)*	MT 412 Financial Mathematics (3 credits) *
MT 409 Selected Topics in Applied Operations Research (2 credits)	MT 410 Optimization for Engineering Design *(3 credits)
ST 425/MT 425 Project work /Industrial training (3 credits) #*	

** : Compulsory courses # : Courses including practical*

The following existing courses cannot be offered by the students who follow this degree programme.
MT 101, MT 103, MT 311, MT 407, CS 201, CS 203

The following course units maybe of interest to the students:
Numerical Analysis, Economics, Environmental Science, Genetic Engineering, Geographical Information Systems, Management studies.

100 LEVEL COURSES

ST 101 Introduction to Statistics (3 credits)
Basic ideas in Statistics : Representation of data, Histogram, Frequency polygon, Ogive.
Measures of Location : Various Means (AM, GM, HM, TM), Median, Mode, Quantiles, Deciles, Percentiles. Measures of Dispersion : Range, Interquartile range, Variance, Standard deviation, Chebyshev's rule for sample, Shepperd's correction for variance, Coefficient of variance, Moments of higher order, Skewness, Kurtosis.
Representation of data using Stem-Leaf diagrams and Box plots.
Regression and Correlation: Scatter diagrams, Linear Regression, Method of least squares,Correlation, Coefficient of correlation, Rank correlation, Spearman's rank correlation coefficient.
Index numbers: Introduction, Price Relatives, Quantity Relatives and Value Relatives. Link and Chain Relatives, Cost of living Index Numbers, Methods of construction of Index Numbers, Quantity Index Numbers, Tests for Index numbers.

Recommended texts
1. *Statistical methods*, J.Medhi.
2. *A Basic Course in Statistics*, G.M.Clarke,and D.Cooke

ST 102 Introduction to Probability Theory (3 credits)
Counting Techniques: Combinations, Permutations, Set partitions,
Elements of Probability: Experiments, Events, Sample space, Laws of Probability, Bayes' Theorem, Independence of events. Random variables: Discrete and continuous r.v.'s, Probability mass function, Probability density function, Cumulative distribution function, Functions of a random variable, Expectation, Moments, Mean and variance, Moment Generating function.
Probability inequalities: Chebyshev's and Markov's etc.
Distributions: Discrete: Uniform, Bernoulli & Binomial, Poisson, Geometric, Negative Binomial, Hypergeometic, Multinomial, Continuous: Uniform, Normal, Gamma, Exponential, Properties and applications of distributions, Probability Generating functions.
Approximation to Binomial using Poisson, Binomial using Normal, and Poisson using Normal.

Recommended Texts
1. A*pplied Probability and Statistical Methods*, G.C.Canovos .
2. *Basic Course in Statistics*, G.M.Clarke and D. Cooke
3. *A Course in Probability & Statistics*, C.J. Stone

ST 103 Statistics Applications I (1 credit)
(Prerequisite: ST 101 or any other Basic Statistics course)
Introduction to MINITAB, Data management: Editing, summarizing, Transforming and Manipulating Data, Graphical methods for describing data, Numerical methods for describing data, Distributions and Random data. Applications.

Recommended Text
1. *MINI TAB Reference manual*

ST 104 Statistics Applications II (1 credit)
(Prerequisite: ST 101 or any other Basic Statistics course)
Introduction to the SAS Display manager system, Structure of a SAS program, Editing, rearranging, displaying and summarizing data using PROC PRINT, PROC SORT, PROC FREQ, PROC MEANS, PROC UNIVARIATE, PROC FORMAT, PROC CORR PROC TABULATE, PROC STANDARD, PROC RANK etc. Creating Graphics using PROC PLOT, PROC CHART etc.
SAS Expressions, SAS Functions, Some SAS statements (ARRAY, DELETE, DO, DROP, FORMAT, GO TO, IF, INFILE, INFORMAT, INPUT, KEEP, LABEL MERGE, OUTPUT, PUT, SET, ID, VAR, TITLE, LIBNAME ETC.)Applications.

Recommended texts:
1. *SAS Reference manual*

CS 101 Introduction to Computer Science (3 credits)
Introduction and overview : Intelligent machines and systems applications, Business, Communications, Educational, Engineering, Environmental, Medical and Scientific applications.
Introduction to computing concepts : Basics of computer programming : data types, declarations, assignments, basic input and out put ASCII files, built-in functions.
Structured programming ideas : selection statements: sequence, iteration (counting loops, while loops, file pointers), conditional (if-then-else statements ,case statements) ,matrix manipulations (addition, subtraction, multiplication, transposition).
Modular programming : functions, procedures with actual and formal parameters, simple sort algorithms, dynamic memory allocation and addressing.
Numerical methods: Linear interpolation, linear regression, pseudo random , roots of functions, solutions of simultaneous linear equations by Gaussian elimination, numerical integration.

Recommended Texts
1. The Thinking Ape: Evolutionary Origins of Intelligence, R. Byrne.
2. Intelligent Multimedia System : A Handbook for Creating Applications, R.M.Kaplan
3. Artificial Intelligence, E.Rich and K. Knight

CS 102 Programming Techniques (3 credits)
Basic concepts, basic components of programming languages, binding, simple algorithms operating on non-structured data, modularity in program construction.
Basics of constructing larger programs :abstraction and instantiation of program components, structured data (lists, stacks, queues, ordered binary trees), storing and accessing data structures, operations on mutable data, working with mutable data, object-based programming, data encapsulation

Recommended Texts:
1. *Data Structures, Algorithms,and Object-oriented Programming*, G.L. Heileman.
2. *Structured programming concepts*,K. Labudde

CS 103 Programming Laboratory I (2 credits)
(Prerequisites: CS 101, CS 102, which shall be taken concurrently (1 cr. per semester))
Language constructs : data declarations, loops, decision structures ,input/output, files, subprograms / procedures, numeric and non-numeric data. Design and construction of software: top-down and bottom-up design, decomposition, structuring, design for reuse, documentation, study of examples, writing software as a team, using software from others.
Programming assignments: A variety of progressively more complex assignments.
(Sections are offered in C,C++ and Java)

Recommended texts:
1. *Turbo C++*, F. Bryan Byron S. G. (1990),
2. *Theory and Problems of Programming in C*, S.G.Byron,Schaum's Outline Series
3. *JAVA: How to Program*, H.M. Deitel and P.J. Ditel
4. *Mastering JAVA* , J. Zukowski .

MT 105 Real Analysis I (3 credits)
Real number system as a complete ordered field, Complex number system, Topology of the real line, Neighborhoods, Sequences and limits, Limit theorems, Monotonic Sequences, Limit Concept of a Real-Valued Function, Algebra of limits, Continuity, Monotonic functions, Differentiability, Role's Theorem, Mean-Value Theorems, L'Hospital's Rule, Riemann Integral and the basic properties. Fundamental theorem of Calculus, Improper integrals.

Recommended text:
1. *Elementary Real Analysis,* H.G. Eggleston
2. *Analysis,* S.R. Lay

MT 107 Mathematics for Operations Research (3 credits)
Vector methods: Introduction to vectors, Linear combinations, Linear dependence and independence, Bases and dimension, Scalar product, Vector product
Differential equations: First order ordinary differential equations, Exact equations, Higher order linear ordinary differential equations with constant coefficients
Linear Algebra: Preliminaries, Determinants, Simultaneous linear equations, Eiganvalues and eiganvectors, Matrix calculations, Special matrices, Range and null space, Decomposition of matrices, Quadratic forms. Differentiation of scalar functions of matrices.

Recommended Texts:
1. *Elementary Vector Analysis,* C.E. Weatherburn,(1982)

2. *A First Course in Differencial Equations,* D.G. Zill, (1998)
3. *Linear Algebra,* K. Hoffman and R. Kunze, (1999)

MT 108 Operations Research I (2 credits)
Introduction to Operations Research, Operations Research methods: Probabilistic and Deterministic.

Recommended Text:
1. *Operations Research,* Kanti Swarup.(1987)

MT 109 Linear Programming (3 credits)
(Prerequisites: MT 107, MT 108)
Introduction, Convex sets and functions, The Simplex method, Big-M method, Revised simplex method, Dual simplex method, Sensitivity analysis, Introduction to LINGO.
Some practical assignments will be given for this course.

Recommended Text:
1. *Linear and Nonlinear Programming,* David G. Luenberger,(1997)
2. *Operations Research,* Kanti Swarup.(1987)

200 LEVEL COURSE

ST 201 Probability Theory (3 credits)
(Prerequisite: ST 102)
Joint distribution of two (or more) discrete or continuous random variables, Marginal distribution, Conditional distribution, Independence of random variables, Expectation, Conditional expectation, Covariance, Correlation coefficient, Transformations involving two or more random variables, Probability density functions of (a) sum and difference, (b) product and quotient of two random variables,
Random samples, Empirical distributions, Order statistics, Distributions of MIN X_i, MAX X_i etc., Distributions of sample mean and sample variance; t, F and χ^2 distributions and their properties, Laws of large numbers, Central limit theorem.

Recommended texts
1. Canavos G.C. (1984), *Applied Probability and Statistical methods*
2. Freund J.E. (1994) *Mathematical Statistics*, Prentice Hall
3. Wackerly D. Mendenhall W. & Scheaffer R.L. (1995) M*athematical Statistics with Applications,* Duxbury Press.

ST 203 Theory of Statistics (3 credits)
Some practical assignments will be given for this course. (Prequisite: ST 201)
Estimation: Point estimation: Properties of estimators; Unbiasedness, Consistency, Relative efficiency, Efficiency, Sufficiency, Factorization theorem, Rao-Blackwell theorem, UMVUE, Exponential families, Cramer-Rao inequality, Methods of obtaining estimators; Method of moments, Maximum likelihood estimators etc.
Interval estimation: Constructing confidence intervals for population parameters under various assumptions, Tolerance limits.
Testing Hypothesis: Tests on population parameters, Tests on independent and paired samples, Neyman-Pearson lemma, Uniformly Most Powerful tests, Likelihood Ratio tests.

Recommended texts
1. Canavos G.C. (1984) *Applied Probability and Statistical methods*, Little, Brown & Company.
2. Freund J.E. (1994) M*athematical Statistics*, Prentice Hall
3. Hogg R.V. (1978) & Craig A.T., *Introduction to Mathematical Statistics*, Prentice Hall .

ST 204 Sampling Techniques (2 credits)
Some practical assignments will be given for this course. (Prequisite: ST 203)
Principal steps in a Sampling Survey, Probability sampling, Simple random sampling, Sampling proportions and percentages, The estimation of sample size, Stratified random sampling, Methods of allocations, Ratio estimators, Regression estimators, Introduction to Cluster sampling and Systematic sampling, Estimating the population size.

Recommended texts
1. Cochran W.G. (1977) *Sampling Techniques*, John Wiley & Sons.
2. Scheaffer R.L. (1996) Mendenhall W., and Ott L., E*lementary Survey Sampling*, Duxbury Press.

ST 205 Statistical Simulation (2 credits)
(Prerequisites: CS 102, CS 103, ST 203)
Introduction and overview of simulation analysis, Modeling and estimating input processes, Random-number generation, Generation of random variates, vectors, and processes, Statistical analysis of simulation output,

Comparison, ranking, and selection of simulation models, Variance-reduction techniques, Designing simulation experiments, gradient estimation, and optimization, Monte Carlo simulation
Some practical assignments will be given for this course

Recommended Texts:

1. *Simulation Modeling and Analysis,* Law and Kelton (2003)
2. *Graphical Simulation Modeling and Analysis Using Sigma for Windows,* L.W. Schruben(2001)

ST 206 Introduction to Data Mining (2 credits)
(Prerequisites: CS 101, ST 101)
Introduction, Basic Data Mining Tasks, Database / OLTP Systems, Fuzzy Sets and Fuzzy Logic, Information Retrieval, Decision Support Systems, Dimensional Modeling, Data Warehousing, OLAP, Web Search Engines, Statistics, Machine Learning, Pattern Matching.
Data Mining Techniques, A statistical perspective on Data Mining, Similarity Measures, Decision Trees, Neural Networks, Genetic Algorithms. Classification – Statistical Based Algorithms, Distance-Based Algorithms, Decision Tree Based Algorithms
Some practical assignments will be given for this course

Recommended Texts:

1. *Data Mining, Introductory and Advanced Topics,* M.H. Dunham (2003)
2. *Principles of Data Mining,* Hand DJ et al, MIT Press (2001)

CS 207 Statistical Information Processing (3 credits)
(Prerequisites: CS 101, CS 102)
This course cannot be offered by students who offer CS 201 and CS 203.
Data Structures: arrays, structures, linked list, stacks, queues and trees: binary search threes, splay trees, 2-3-4 trees. Analysis of algorithms, sorting algorithms: bubble sort, selection sort, insertion sort, quick sort, heap sort, merge sort and external sorting methods.
Database Management Systems: Introduction, The entity-relationship model, Logical organization of databases; The relational model, Relational algebra, SQL, Physical organization of databases; Concurrency control; Transactions, Serializability, Locking, Recovery, Functional dependencies and normal forms. Statistical applications.

Recommended Texts

1. *Data Structures in Java, Standish, T. A, Addition Wesley (1998)*
2. *An Introduction to Database Systems; Date C.J. Addison Wesley(2000)*

CS 208 Programming in Statistical Information Processing (2 Credits: 1 Credit per semester)
(Prerequisite: CS 207)
Computer programming using database management packages, Programming Assignments: A variety of progressively more complex assignments.

Recommended Texts:

1. *Java How to Program;* Deitel. H. M.;Ditel P.J.; Prentice Hall (1999)
2. *Oracle 8i The complete reference,* Loney, K. Koch GMcGraw Hill (2000)

MT 202 Real Analysis II (3 credits)
(Prerequisite: MT 105)
Cauchy sequences, Convergence tests, Absolute and conditional convergence, Power series, Integration and differentiation of power series, Taylor series, Uniform continuity, Upper and lower Riemann integrals, Characterization of Riemann integrable functions, Functions of several variables, Limits and continuity, Partial derivatives, Differentials, Chain rule, Extrema of functions of several variables, Lagrange Multipliers.

Recommended Texts:

1. S. R. Lay (1986), *Analysis An Introduction to Proof,* Prentice-Hall
2. T. M. Apostol (1974), *Mathematical Analysis*, Addison-Wesley

MT 204 Mathematical Methods (3 credits)
(Prerequisite: MT 101)
Differentiation of Vectors: Scalar and vector point functions and their partial derivatives with respect to coordinate variables, Gradient of a scalar point function; Directional derivative, Divergence and curl of a vector point function**.**
Integration of Vectors: Line integrals and their evaluation using parametric representation, Surface integrals, Green's theorem in the plane Stokes theorem, Circulation and flux of a vector point function, Volume integrals, Divergence theorem, Irrotational and Solenoidal vector fields, Orthogonal Curvilinear Coordinates, Grad, Div, Curl in OCC,

Cylindrical polar and spherical coordinate systems, Use of these coordinate systems in evaluation of surface and volume integrals. **Special Solution of Laplaces Equation:** Solutions in two-dimensions, Axi-symmetric solutions. **Integral Transforms:**
Laplace transforms; Elementary Properties, Inverse Laplace transform and its properties, Convolution theorem and its use in evaluation of integrals, Uses of Special functions connected with Laplace transform, Evaluation of integrals using LT, Applications in ODE and integro-differential equations, Applications in PDE, Fourier Transforms; Infinite-Fourier sine/cosine transforms and their inverse formulae, Finite-Fourier sine/cosine transforms, Derivation of inverse formulae, Use of Fourier series, Boundary value problems-Use of Fourier transforms.

Recommended Texts:

1. M.R. Spiegel (1968), *Vector Analysis*, McGraw-Hill
2. M.D. Raisinghania (1997), *Vector Analysis*, S. Chand & Comp. Ltd.
3. M.D. Raisinghania (1995), *Integral Transforms*, S. Chand & Comp. Ltd.

MT 209 Graph Theory (2 credits)
Isomorphism of Graphs, Paths, Circuits, Eulerian graphs, Hamiltonian graphs, Shortest path problem, Chinese postman problem, Directed graphs, Graph Colouring, Four colour problem, Proof of five colour theorem, Planar graphs, **Trees and Searching:** Properties of trees, Travelling salesman problem, Tree Analysis of sorting algorithms, Hall's Theorem, Transversal theory, Applications to game theory.

Recommended Texts:

1. F. Harary (1988), *Graph Theory*, Narosa Publishing House
2. R. J. Wilson (1996), *Introduction to Graph Theory*, Addison-Wesley Longman

MT 210 Advanced Linear Programming (3 credits)
(Prerequisite: MT 109)
Transportation problem, Assignment problem, Goal programming, Dantzig-Wolf Decomposition algorithm, Interior point algorithms, Bounded variable Simplex algorithm.
Some practical assignments will be given for this course.

Recommended Text:

1. *Linear programming and Network Flows*, Mokhtar S. Bazaraa, Operations Research, Kanti Swarup, (1997)

MT 211 Integer Programming (3 credits)
(Prerequisite: MT 210)
Introduction to Integer Programming, Modeling and applications, Dual of Primal Cutting Plane algorithms, Branch and Bound Enumerations, Search Enumerations, Partitioning in Mixed Integer Programming, Group Theory in Integer programming.
Some practical assignments will be given for this course.

Recommended Text:

1. *Integer programming, Applications and Computations*, Hamdy A. Taha., (1998)

MT 212 Operations Research II (2 credits)
(Prerequisite: MT 109)
Theory of games, Queuing theory, Inventory management.

Recommended Text:

1. *Operations Research*, Kanti Swarup., (1987)

300 LEVEL COURSE

ST 301 Regression Analysis (3 credits)
Some practical assignments will be given for this course. (Prequisite: ST 203)
Simple linear regression, Tests for regression coefficients, Interval estimation, Prediction, Analysis of variance approach, Diagnostic and remedial measures, Matrix approach to simple linear regression, Multiple regression, Polynomial regression. Introduction to logistic regression and nonlinear regression, Introduction to Time series Analysis.

Recommended texts

1. Myers R.H. (1990) *Classical and Modern Regression with Applications*, Duxbury Press
2. Neter J. (1990) wasserman W. & Kunter M.H., A*pplied Statistical Models*, Irwin Inc.
3. Christensen R. (1998) A*nalysis ofVvariance, Design and Regression*, Chapman & Hall/CRC

ST 302 Quality Control (2 credits)

Some practical assignments will be given for this course. (Prequisite: ST 203)

Control charts for mean, variance, range etc, Properties of control charts, Acceptance sampling procedures and consumer risks, Operating characteristic curves, Process capability analysis, Introduction to Quality assurance and acceptance control, Lot-by-Lot acceptance sampling by attributes, Acceptance procedure based on AQL, Other acceptance procedures, Continues acceptance sampling by attributes, Acceptance procedures for variable characteristics.

Recommended texts

1. Hansen B.L. (1987) & Ghare P.M., *Quality Control and Application*, Prentice Hall
2. Montogomery D.C. (1993) I*ntroduction to Statistical Quality Control*, John Wiley & Sons.

ST 303 Design and Analysis of experiments (3 credits)

Some practical assignments will be given for this course. (Prerequisite: ST 203)

Comparison of two samples (independent, dependent), One-way ANOVA: Assumptions, Normal theory, F-tests. Multiple comparisons: LSD method, Tuckey's method, Bon- ferroni method, Scheffe's method, Duncan's multiple range method.

Two-way ANOVA: Normal theory, Randomized block design, The two factor factorial, Multifactor Factorials, Confounding, Introduction to Analysis of covariance, Latin square.

Recommended texts

1. Jobson J.D. (1991) A*pplied multivariate data analysis*, *Vol. I : Regression and Experimental Design*, Springer
2. Neter J. (1990) Wasserman W. & Kunter M.H., A*pplied Statistical Models*, Irwin Inc.
3. Lindman H.R. (1992) A*nalysis of Variance in Experimental Design*, Springer Series.

ST 304 Non- parametrics and categorical data Analysis (2credits)

Some practical assignments will be given for this course. (Prerequisite: ST 203)

Non-Parametrics : One sample sign test, Binomial test, Two sample sign test, Wilcoxon paired samples, Signed rank test, Wilcoxon and Mann Whitney test, Correlation tests, Tests of independence, Wald- Wolfowitz runs test, Kruskal-Wallis test, Friedman test.

Categorical Data Analysis : Multinomial distribution, Goodness of fit tests, The Kolmogorov-Smirnov Statistics, Testing for Normality, Contingency tables, Testing for Independence, Testing for homogeneity.

Recommended texts

1. Sprent P. (1989) A*pplied Nonparametric Statistical methods*, Chapman & Hall
2. Gibbons J.D. (1990) & Chakrabortic S., *Nonparametric Statistical Inference*, Marcel Dekker Inc.

ST 305 Multivariate Methods I(2 credits)

(Prerequisite: ST 203)

Properties of random vectors and Matrices, The Multivariate Normal distribution, Estimation of parameters in the Multivariate Normal distribution, Wishart distribution, Inferences on multivariate mean, and Hotelling's T^2 tests, Multivariate Analysis of Variance, Cluster Analysis.

Some practical assignments will be given for this course

Recommended Texts:

1. *Multivariate Statistics - A Practical Approach*, Flury B and Riedwel H,l (1998)
2. *Multivariate Statistical inference & Applications*, A.C. Rencher (1982)

ST 306 Data Analysis & Preparation of Reports (1 credit)

(Prerequisites: ST 301, ST 302)

Students will be grouped, and assigned instructors. The skills of data analysis, statistical software development and report writing will be given. Initially the student groups are given case studies. Gradually the students will be assigned small projects taken from Industry. At the end of the course students are expected to write reports of their findings.

Recommended Text:

1. *SAS Reference Manuals*

ST 307 Time series (2 credits)

(Prerequisites: ST 203, ST 301)

Introduction; Objectives of time series analysis, Components of time series, Traditional method of time series analysis; Estimation of trend, seasonal effect forecasting; Auto-correlation & Auto-covariance functions Correlogram; Probability models for time series; Stationary processes; Second order stationary processes; Purely random processes; Random walk; Moving average processes; Auto-regressive processes; Mixed models (ARMA, ARIMA); Estimation of parameters; Testing adequacy; Forecasting; Exponentially smoothing forecasting procedure; Non Stationary and Seasonal Time series models (SARIMA); Box-Jenkins forecasting procedure. Introduction to non linear models and Multivariate time series modelling

Some practical assignments will be given for this course

Recommended Texts:

1. *Introduction to Time Series and Forecasting,* P.J. Brockwell and R.A. Davis (2000)
2. *The Analysis of Time Series, An Introduction,* C. Chatfield (1998)

ST 308 Bayesian Statistics I (2 credits)
(Prerequisite: ST 203)
Introduction: Statistical and Non-statistical decisions, Profit, Loss, Risk and utility, Expected Value, Bayes' Theorem, Prior Distribution, Bayesian Inference; Non-statistical Decisions: Maximin, Maximax, Minimax Regret and Hurwicz.

Recommended Texts:

1. *Statistical Decision Theory and Bayesian Analysis,* J.O. Berger (1985)
2. *Bayes and Empirical Bayes methods for Data analysis,* B.P. Carlin and T.A. Louis (1996)

ST 325/MT 325 Seminar (1 credit)
(Prerequisies: ST 306, ST 307)
A student is expected to carry out an extensive literature survey on a topic assigned to him/her by a senior staff member. At the completion of the course the student is expected to write a report of not less than ten pages, and make a presentation.

CS 302 Design and Analysis of Algorithms (1 credit)
(Prerequisies: CS 207, CS 208)
Divide & Conquer Algorithms, Dynamic Programming, Greedy Algorithms, Greedy Algorithms as Heuristics, Recursive Algorithms, Backtracking, Alfa-Beta pruning, Branch & Bound Search, Analysis of Algorithms, Time Complexity, Sorting Algorithms - Bubble Sort, Insertion Sort, Tree Sort, Quick Sort, Selection Sort, Heap Sort, External Sorting Techniques - two way Merge Sort, Searching Algorithms - Sequential Search, Binary Search, Fibonacci Search, NP completeness.

Recommended Text:

1. Cormen , T.H. et al; *Introduction to Algorithms* ; McGraw Hill;1990

MT 304 Partial Differential Equations (2 credits)
(Prerequisite: MT 103)
First order partial differential equations: Linear equations, Non-linear equations, Characteristics.
Second order partial differential equations: Equations with constant coefficients, Equations with variable coefficients, Laplace equation, Wave equation, Diffusion equation, Boundary value problems,
Use of Fourier series.
Numerical methods of solving partial differential equations.

Recommended Texts:

1. R. V. Churchill & J.W. Brown (1987), *Fourier Series and Boundary Value Problems*, McGraw-Hill
2. E.T. Copson (1975) *Partial Differential Equations*, Cambridge University Press

MT 313 Convex Analysis (2 credits)
(Prerequisite: MT 202)
Convex sets, Convex functions, Continuity and Differentiability of convex functions, Minimum and maximum of a Convex function over a Convex set, Lagrange multipliers, Minimax theorems and duality, Saddle-functions

Recommended Text:

1. *Convex Analysis,* R. Tyrell Rockafellar.(1987)

MT 314 Network Optimization Theory (3 credits)
(Prerequisite: MT 210)
Introduction, Paths, Trees and Cycles, Shortest Paths, Maximum flows, The Traveling Salesman problem.

Recommended Text:

1. *Linear programming and Network Flows,* Mokhtar S. Bazaraa. (1997)

MT 315 Operations Research III (2 credits)
(Prerequisites: MT 109, MT 314)
Simulation, Network Scheduling, Information Theory.

Recommended Text:

1. *Operations Research,* Kanti Swarup. (1982)

MT 316 Non-Linear Programming (3 credits)

(Prerequisite: MT 210)

Quadratic programming, Dynamic programming, Geometric programming, Probabilistic programming, Fractional programming, Gradient Search methods.

Recommended Text:

1. *Linear and Nonlinear Programming, David G. Luenberger,* Operations Research, Kanti Swarup, (1997).

400 LEVEL COURSES

ST 401 Actuarial Statistics (2 credits)

(Prerequisite: ST 203)

Economics of uncertainty. Risk theory and utility. Jensen's inequality. Sums of random variables and convolutions. Applications to individual risk models. Failure rates and the force of mortality. Mixtures of random variables and mixtures of distributions. Loss distributions, Reinsurance. Risk models, Estimating distribution by simulation. Actuarial applications of statistical inference. Compound distribution. Collective risk models. Ruin theory. Lundberg's Inequality, Introduction to credibility theory. Compound stochastic processes. Applications of risk theory in insurance problems. No claims discounting. Run off triangles.

Recommended Texts:

1. *An Introduction to the Mathematics of Finance* (Chapters 1-4), J.J. McCutcheon and W.F. Scott.,(1998)
2. *Life Contingencies* (Chapters 1-6)A. Neill.(1999)
3. *Actuarial Mathematics* (Chapters 3-8), N.L. Bowers Jr, ... [et al.].(2001)
4. *Mathematical Models for the Growth of Human Populations,* .H. Pollard (1997)

ST 402 Statistical Data Mining (3 credits)

(Prerequisites: ST 206, ST 305)

Classification –Neural Network Based Algorithms, Rule Based Algorithms, Combining Techniques.

Clustering – Similarity and Distance Measures, Hierarchical Algorithms, Partitional Algorithms, Clustering Large Data Bases, Clustering with Categorical Attributes, Comparison.

Association Rules – Large Item Sets, Basic Algorithms, Parallel and Distributed Algorithms, Comparing Approaches, Incremental Rules, Advanced Association Rule Techniques, Measuring the Quality of Rules.

Web Mining – Web Content Mining, Web Structure Mining, Web Usage Mining.

Spatial Mining – Spatial Data Overview, Spatial Data Mining Primitives, Generalization and Specialization, Spatial Rules, Spatial Classification Algorithm, Spatial Clustering Algorithms.

Temporal Mining – Modeling Temporal Events, Time Series, Pattern Detection, Sequences, Temporal Association Rules.

Some practical assignments will be given for this course

Recommended Texts:

1. *Data Mining Introductory and Advanced topics,* M.H. Dunham (2003)
2. *Predictive Data Mining,* Weiss SM & Indurkhya N, Morgan Kaufmann (1997)
3. *Principles of Data Mining,* Hand DJ et al, MIT Press (2001)

ST 403 Statistics for Bioinformatics (2 credits)

(Prerequisites: CS 207, CS 208)

Review of the following in the context of bioinformatics: Basic probability, statistical inference, stochastic processes, computer intensive approaches to statistical inference, applications. Mathematical models and computational methods of statistical genetics including mendelian genetic traits, population genetics, pedigree relationships and gene identity, meiosis and recombination, linkage detection, multipoint linkage analysis. Course work involves some computation in a Unix environment.

Recommended Texts:

1. *Biological Sequence Analysis,* R. Durbin, S. Eddy, A. Krogh and G. Mitchison (1998)
2. *Statistical Methods in Bioinformatics, An Introduction,* W. J. Evans, G.R. Grant (2001)

ST 404 Stochastic Processes (2 credits)

(Prerequisites: ST 201, ST 203)

Introduction to Stochastic processes: Markov Chains, Markov Processes with Discrete state space, Markov Processes with Continuous state space, Stationary processes, Branching Processes, Stochastic processes in Queueing and

Reliability

Recommended Text:

1. *Stochastic Processes*, J. Medhi (1996)

ST 405 Multivariate methods II (2 credits)

(Prerequisite: ST 305)

Discriminant analysis of two group and multiple groups, Principal component analysis (PCA). Interpretation using illustrative examples. Factor analysis. Comparison with PCA, factor loadings, rotations, Interpretation, Canonical correlation, Covariance structure models.

Some practical assignments will be given for this course

Recommended Texts:

1. *Multivariate Statistical inference & Applications,* A.C. Rencher(1990)
2. *Applied Multivariate Statistical Analysis,* R.A. Johnson and D.W. Wichern (1982)

ST 406 Bayesian Statistics II (2 credits)

(Prerequisite: ST 308)

Decision Rules; Making Decisions when data is not available: Specifying a prior distribution, Making decisions with only prior information; Making Decisions when data is available: Decision trees, Expected Value of Perfect Information (EVPI), Expected Value of Sample Information (EVSI), Non-informative and natural conjugate prior, Bayesian confidence intervals.

Recommended Texts:

1. *Statistical Decision Theory and Bayesian Analysis,* J.O. Berger (1985)
2. *Bayes and Empirical Bayes methods for Data analysis*, B.P. Carlin and T.A. Louis (1996)

ST 425/MT 425 Project Work/Industrial Training (3 credits)

Students are expected to carry out an independent research project on a topic assigned to him/her under the supervision of a senior staff member or spent 6 weeks in industry working in a relevant project. At the completion of the project students are expected to write a report and make a presentation.

CS 403 Artificial Neural Networks (3 credits)

(Prerequisites: CS 207, CS 208, CS 302)

Parallel and distributed processing, Neuron, Connectivity, Activation function, propagation rule, Learning rules, pattern Preparation, Perceptron, Multilayer perceptron, Associative memory, Hopfeld neural networks, Self organizing map (SOM), Adaptive Resonance theory, topologies, Training methods, supervised and unsupervised learning.

Recommended Text:

1. Haykin, S.; *Neural Networks: A comprehensive foundation*; Prentice-Hall; 1999

CS 405 Fuzzy Logic and Modeling (3 credits)

(Prerequisites: CS 207, CS 208, CS 302)

Fuzzy system models, Fuzziness and certainty, fuzzy sets, basic properties and characteristics, Domains, Alpha- level sets and support sets, Linear representation, Fuzzy set operators, Conventional (crisp) set operations, basic Zadeh type operations, intersection, union and complement of fuzzy sets, General algebraic operations, Fuzzy set hedges, Fuzzy reasoning, linguistic variables, Fuzzy models, Fuzzy systems and modeling, Design methodologies, modeling and utility software.

Recommended Text:

1. Nguyan H.T.; Walkey E.A; *A first course in Fuzzy Logic*; Chapman and Hall; 1996.
2. Ross T.J.; *Fuzzy Logic with Engineering Applications*; McGraw Hill ;1995

MT 409 Selected Topics in Applied Operations Research (2 credits)

(Prerequisites: MT 315, MT 316)

Topics will be selected from significant areas in Operations Research. Topics may vary each year.

MT 410 Optimization of Engineering Design (3 credits)

(Prerequisites: MT 315, MT 316)

Introduction, Single-variable optimization algorithms, Multivariable optimization algorithms, Constrained optimization algorithms, Specialized algorithms, Nontraditional optimization algorithms.

Recommended Text:

1. *Optimization for Engineering Design* (*Algorithms and Examples*), Kalyanmoy Deb, (1999)

MT 411 Optimization Modeling (2 credits)
(Prerequisites: MT 315, MT 316)
Optimization models in Linear programming, Nonlinear programming and Integer programming. Students are expected to develop reasonable modeling skills allowing them to cast appropriate real world problems as optimization problems and solve them with available software.

MT 412 Financial Mathematics (3 credits)
An introduction to options and markets, Interest and present value analysis, Geometric Brownian Motion, Pricing contract via arbitrage, Arbitrage theorem, Black-Scholes option pricing formula, The binomial option pricing model, More results on options, Valuing by expected utility, Exotic options.

Recommended Texts:

1. *An Elementary Introduction to Mathematical Finance. Options and other Topics*, S.M. Ross, (1987)
2. *The Mathematics of Financial Derivatives, A student Introduction*, P. Wilmott, S. Howisan, J. Dewynne,(2000)
3. *Options, Futures and other Derivatives*, J. Hull, Prentice Hall,(1998)