NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
DEPARTMENT OF MATHEMATICAL AND COMPUTATIONAL SCIENCES

Credit Structure & the contents of the B.Tech. programme in Computational and Data Science

1. Proposed Credit Structure & the contents of the B.Tech. programme in Computational and Data Science

1.	Foundation Courses	38
2.	Programme Core	70
3.	Elective Courses	30
4.	Major Project	06
5.	Mandatory Learning Courses	16

TOTAL CREDITS: 160

Bachelor of Technology in Computational and Data Science

Foundation Courses

Basic Science Core (BSC)

MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics – II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1
CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2

Engineering Science Core (ESC)

AM110	Engineering Mechanics	(3-0-0) 3
ME111	Engineering Graphics	(1-0-3) 3
CS100	Python Programming	(3-0-0) 3
CS101	Python Programming Lab	(0-0-3) 2
EC100	Elements of Electronics and Communication Engineering	(2-0-0) 2

Humanities and Social Science Core (HSC)

SM110	Professional Communication	(3-0-0) 3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Program Core (PC)

MA112	Digital System Design	(4-0-0) 4
MA113	Linear Algebra	(4-0-0) 4
MA202	Discrete Mathematical Structures	(3-0-0) 3
MA207	Numerical Methods	(3-0-0) 3
MA208	Probability Theory and Applications	(3-0-0) 3
MA221	Data Structures	(3-0-0) 3
MA222	Computational Linear Algebra	(3-0-0) 3
MA223	Computer Org & Arch	(3-0-0) 3
MA224	DS Lab	(0-0-3) 2
MA225	COA Lab	(0-0-3) 2
MA226	Operating Systems	(3-0-0) 3
MA227	Database Systems	(3-0-0) 3
MA228	Operating Systems Lab	(0-0-3) 2
MA229	Database Systems Lab	(0-0-3) 2
MA302	Data Analysis, Time Series Analysis And Non-Parametric Methods	(3-0-0) 3
MA303	Integral Transforms and Applications	(3-0-0) 3
MA321	Fundamentals of Data Science	(3-0-0) 3
MA322	Design & Analysis of Algorithms	(3-0-0) 3
MA323	Statistical Methods Lab	(0-0-3) 2
MA324	DAA Lab	(0-0-3) 2
MA325	Machine Learning	(3-0-0) 3
MA326	Theory of Finite Automata, Formal Languages and Computation	(3-0-0) 3
MA327	Scientific Computing Lab	(0-0-3) 2
MA406	Statistical Design and Analysis of Experiments	(3-0-0) 3

Program Specific Electives (PSE)

MA206	Number Theory and Cryptography	(3-0-0) 3
MA405	Reliability Theory and Applications	(3-0-0) 3
MA500	Capstone Project	4
MA506	Quadratic Forms and Linear Algebra	(3-0-0) 3
MA507	Image Processing	(3-0-0) 3
MA508	Soft Computing	(3-0-0) 3
MA509	Combinatorial Optimization	(3-0-0) 3
MA514	Pattern Recognition	(3-0-0) 3
MA515	Statistical Techniques for Data Mining	(3-0-0) 3
MA516	Software Engineering	(3-0-0) 3
MA517	Algorithmic Combinatorics	(3-0-0) 3
MA518	Selected Topics in Graph Theory	(3-0-0) 3
MA519	Systems Modelling and Simulation	(3-0-0) 3
MA520	Selected Topics in Computer Algorithms	(3-0-0) 3
MA521	Mobile Computing	(3-0-0) 3
MA523	Computer Networks	(3-0-0) 3
MA527	Network Security	(3-0-0) 3
MA529	Advanced Data Science	(3-0-0) 3
MA531	Statistical Quality Control	(3-0-0) 3
MA533	Wavelets in Data Science	(3-0-0) 3
MA534	Cloud Computing	(3-0-0) 3
MA535	Distributed Computing Systems	(3-0-0) 3
MA536	Advanced Database Systems	(3-0-0) 3
MA537	Optimization Techniques	(3-0-0) 3

Open Electives (OE)

MA201	Concrete Mathematics	(3-0-0) 3
MA401	Computational Fluid Dynamics	(3-0-0) 3
MA403	Mathematical Modelling	(3-0-0) 3
MA408	Stochastic Analysis and Applications	(3-0-0) 3
MA512	Numerical Solutions of Differential Equations	(3-0-0) 3
MA513	Modern Algebra	(3-0-0) 3
MA525	Computational Number Theory	(3-0-0) 3
MA526	Game Theory	(3-0-0) 3
MA528	Introduction to Parallel Programming	(3-0-0) 3
MA532	Big data Analytics	(3-0-0) 3
MA538	Artificial Intelligence	(3-0-0) 3

Program Major Project (PMP)

MA498	Major Project phase 1	(0-0-3) 2
MA499	Major Project phase 2	(0-0-6) 4

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
SM111	Professional Ethics and Human Values	(1-0-0) 1
MA490	Practical Training	1
MA491	Seminar	1
ME100	Introduction to Design Thinking	(2-0-0) 2
SA401	Liberal arts courses/ cocurricular / extracurricular activities	10

1. Proposed Semester wise scheduling of courses: (Sem1 and Sem2 are Foundation courses)

Semester	I	II	III	IV	V	VI	VII	VIII
1	MA110	MA111	MA221	MA208	MA321	MA325	MA421	Elective 7
2	CY110	PH110	MA202	MA226	MA322	MA326	SM302	Elective 8
3	CY111	PH111	MA222	MA207	MA302	SM300	MA406	Elective 9
4	AM110	EC100	MA223	MA227	Elective 2	Elective 3	Elective 5	Elective 10
5	CS100	ME111	MA303	Elective 1	MA323	Elective 4	Elective 6	MA499
6	CS101	SM110	MA224	MA228	MA324	MA327	MA498	-
7	CV110	SM111	MA225	MA229	MA490	MA491	SA401	-
8	MA112	MA113	-	-	-	-	-	-
9	ME100	-	-	-	-	-	-	-
Total	23	21	19	19	17	18	27	16

Total Credits: 160

2. Program Specific Core (PSC)

MA112 Digital System Design (4-0-0) 4

Basics of logic design, Design of combinational functional blocks (decoders, multiplexers, adder, multipliers, etc.), Sequential circuit design basics, Design of sequential functional blocks - registers and counters, Memory - RAM and ROM, Building simple and pipelined datapaths (ALU, register file and their interconnection paths), Concept of register transfers, Sequencing and control - hardwired control and microprogrammed control, Instruction set architecture.

References:

M. M. Mano and C. R. Kime, Logic and Computer Design Fundamentals, 2nd Edition, Prentice Hall, 2002.

MA113 Linear Algebra (4-0-0) 4

Vector spaces, subspaces, span, linear dependence, basis, dimension. Linear transformations, rank and nullity, matrix representation, change of bases. Rank-Nullity theorem. Inner products, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization, Orthogonal Complement, QR factorization. System of linear equations, echelon matrices, LU-factorization, similarity, determinant, inverse of a matrix, eigenvalues and eigenvectors, symmetric matrices, spectral mapping theorem, characteristic polynomial, Cayley-Hamilton Theorem, Diagonalization of matrices.

References:

G. Strang, Linear Algebra and its applications, Thomson Learning, 2003.

S. H. Friedberg, A. J. Insel, L.E. Spence, Linear Algebra, 4th Edition, Pearson, 2015.

S. Lang, Linear Algebra, 3rd Edition, Springer, 2004.

G. Hadley, Linear Algebra, Narosa, 2000.

W. Cheney, D. Kincaid, Linear Algebra Theory and Applications, Jones & Bartlett, Student Edition, 2010.

3. Program Core

MA202 Discrete Mathematical Structures (3-0-0) 3

Propositional & Predicate Calculus: Introduction to Propositional Logic, Well-formed formulas - Tautology, Contingency, Contradiction, Normal forms, Predicates and Quantifiers, Types of proof techniques, Validity of logical arguments. Graph Theory: Graph Representations, Directed and Undirected graphs - Introduction and basic properties, Subgraphs, Isomorphism, Trees, Spanning Trees, Eulerian and Hamiltonian graphs, Connectivity, Planar graphs, Euler's formula, Applications of Kuratowski's theorem. Groups: Cosets, Normal Subgroups, Permutation groups, Burnside's Theorem and simple applications. Lattice Theory: Equivalence relations, Partial order relations, Linear order relations, Hasse diagrams, Lattices, Lattices as algebraic systems, Special classes of Lattices, Boolean algebra and its properties, Boolean expressions and their canonical forms.

References:

K. H. Rosen, Discrete Mathematics and its applications with Combinatorics and Graph Theory, 7th Edition, 2012.

D. B. West, Introduction to Graph Theory, Eastern Economy Edition published by PHI Learning Pvt. Ltd, 2nd Edition, 2002.

N. L. Biggs, Discrete Mathematics, 2nd Edition (Indian Edition published by Oxford University Press), 2002.

MA207 Numerical Methods (3-0-0) 3

Root finding of polynomials (zeros of a function) and transcendental functions (nonlinear equation), bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. Numerical Integration and Differentiation: Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson's rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multiple integrals, improper integrals, summation of series,

Euler-Maclaurin summation formula, numerical differentiation and estimation of errors. Linear system of equations, LU factorization, Special types of Matrices, Iterative Methods – Jacobi, Gauss-Siedel, SOR methods.

References:

Richard L. Burden and J. Douglas Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010.

W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C/FORTRAN, Prentice Hall of India, New Delhi, 1994.

Jaan Kiusalaas, Numerical Methods in Engineering with MATLAB, 2nd Edition, Cambridge University Press, 2009.

MA208 Probability Theory and Applications (3-0-0) 3

Introduction to probability, Sample space, Definitions of probability, Conditional probability, Bayes' theorem, Random variables, pmf, pdf, cdf, Two and Higher dimensional Random variables, Marginal and Conditional Distributions, Mean and Variance, Covariance and Correlation, Standard probability distributions: Bernoulli, Binomial, Geometric, Poisson, Uniform, Exponential, Normal, Gamma, Moment Generating Functions.

References:

S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press, 2014.

S.M. Ross, Introduction to Probability Models, 10th Edition, Academic Press, 2010.

P.L. Meyer, Introductory Probability and Statistical Applications, 2nd Edition, Oxford & IBH Publishing Co, 1970.

MA221 Data Structures (3-0-0) 3

Abstract data types, Linear Data Structures and their sequential storage representation: stacks, queues, priority queues, and their applications. Pointers and linked storage representation: singly linked list, circular linked list, doubly linked lists and their applications, skip lists. Nonlinear data structures: trees, storage representation of binary trees, operations on binary trees: tree traversals, insertion, deletion, searching, trees, applications of trees. Graphs: representation of graphs, breadth first search and depth first search, shortest path problem, minimum cost spanning trees, applications of graphs. Sorting, Searching, hash tables.

References:

T.H. Cormen, C.E. Leiserson, R.L. Riverst, C.Stein, Introduction to Algorithms, Prentice -Hall of India, 2003.

A.V. Aho, J.E. Hopcraft and J.D. Ullman, Data Structures and Algorithms, Pearson Education, 2003.

J.P. Tremblay and P.G. Sorenson, An Introduction to Data Structures with Application, Tata McGraw-Hill, 1991.

MA222 Computational Linear Algebra (3-0-0) 3

Matrix multiplication problems: Basic algorithms and notations, exploiting structure, block matrices and algorithms, vectorization and re-use issues. Matrix analysis: basic ideas from linear algebra, vector norms, matrix norms, finite precision matrix computations, orthogonality and SVD, projections and the CS decomposition, the sensitivity of square linear systems. General linear systems: Triangular systems, the LU factorization, roundoff analysis of Gaussian elimination, pivoting, improving and estimating accuracy. Special linear systems: The LU and QR factorizations, positive definite systems, banded systems, symmetric indefinite systems, block systems, vandermonde systems and the FFT, Toeplitz and related systems.

References:

Gene H. Golub and Charles F. Van Loan, Matrix Computations, 3rd Edition, Hindustan book agency, 2007.

A.R. Gourlay and G.A. Watson, Computational methods for matrix eigen problems, John Wiley & Sons, New York, 1973.

W.W. Hager, Applied numerical algebra, Prentice-Hall, Englewood Cliffs, N.J, 1988.

D.S. Watkins, Fundamentals of matrix computations, John Wiley and sons, N.Y, 1991.

C.F. Van Loan, Introduction to scientific computing: A Matrix vector approach using Matlab, Prentice-Hall, Upper Saddle River, N.J, 1997.

MA223 Computer Organization and Architecture (3-0-0) 3

Introduction to Computers, Register Transfer and Micro-operations, Computer Arithmetic, Programming the Basic Computer, Organization of a Computer, Input-Output Organization, Memory Organization, Parallel Processing and Vector Processing, Multiprocessors.

References:

John. P. Hayes, Computer System Architecture.

Hwang K., Briggs, Computer Architecture and parallel Processing, 1984.

M.Morris Mano, Computer System Architecture, 3rd Edition, 1993.

MA224 DS Lab (0-0-3) 2

Unix commands, Simple programs using I/O, Implementation of programs using control statements, Implementation of various data structures using object oriented concepts, Functions, Arrays, Pointers, Structures, Unions, File handling, Graphics function and animation.

References:

Brian W.Kernigham and Pike R., The Practice of Programming, Addison Wesley, 1999.

Saumyendra Sengupta, Editors: Carl P. Korobkin, Saumyendra Sengupta, C++, object-oriented data structures, 1994.

MA225 COA Lab (0-0-3) 2

Implementation of Combinational and sequential Boolean circuits using hardware and software.

MA226 Operating Systems

(3-0-0) 3

Operating system functionalities, Types of Operating System-Multi programming, Multi-tasking, Multi-processing and Realtime Operating system, Processes and threads, Process Management (learning fork system call), Inter process communication (using shared memory, Message Queues, Pipes etc.), CPU scheduling, Process synchronization mechanism (Semaphores in Unix), Dead locks - Prevention, avoidance and recovery techniques, Memory Management (Paging, Segmentation and Swapping), Virtual Memory (Dynamic Paging Techniques and Page replacement Algorithms), File Systems Management, IO Management, Protection and Security.

References:

Silberschatz, Galvin, Gagne Operating System Concepts, 6th Edition, John Wiley, 2008.

Mourice J. Bach, The Design of the Unix Operating System, PHI, 2002.

MA227 Database Systems (3-0-0) 3

Files versus database systems, Three-level architecture of databases, Data Models, ER-diagram, EER-model, Relational model, ER-Relational mapping, Relational algebra and calculus. Query languages, SQL, Embedded SQL, Relational database design algorithms, Normalization, Physical database organization, Indexing and hashing, Transaction processing, Concurrency control techniques, Database recovery techniques, Database security and authorization.

References:

RamezElmasri, Shamkant B Navathe, Fundamentals of database system, Addison Wesley, McGraw-Hill, 2000.

Silberschatz, Korth and Sudarshan, Database System Concepts, 6th Edition, McGraw Hill, 2011.

Ramakrishnan, R., Gehrke, Database Management Systems, 3rd Edition, McGraw Hill.

MA228 Operating Systems Lab (0-0-3) 2

Unix Operating System familiarization, UNIX shell scripting, Implementation of IPC using Shared Memory, Pipes, Files, Message queues etc., Process synchronization using Semaphores (Reader writer and Dining Philosopher Problem), Disc scheduling Algorithms.

MA229 Database Systems Lab (0-0-3) 2

Creation of tables, Views, Insertion, Modification and deletion of elements, Implementation of queries, Implementation of joins, Implementation of PL/SQL, triggers, cursors and sub programs, Implementation of database connectivity through front-end tools, Database design and implementation, Mini project.

MA302 Data Analysis, Time Series Analysis And Non-Parametric Methods (3-0-0) 3

Data analysis: Correlation and Regression of data, simple linear regression, Time series analysis: definitions, characteristic movements, measurement of trend, secular trend, seasonal movements, cyclical movements. Non –parametric methods, Wald – Wolfowitz test, sign test, Mann – Whitney U test, signed rank test, Kolmogorov – Smirnov tests, Kruskal – Wallis test.

References:

W.W. Hines and D.C. Montgomery, Probability and Statistics in Engineering and Management Science, John Wiley.

J. Medhi, Statistical Methods, Wiley Eastern.

MA303 Integral Transforms and Applications (3-0-0) 3

Laplace Transforms: solutions of boundary value problems using Laplace transforms, Applications of Laplace Transforms to the solutions of partial differential equations.

Fourier Transforms: Fourier sine and cosine transforms, Applications of Fourier Transforms to the solutions of ordinary differential equations and partial differential equations.

Hankel and Mellin and z–Transforms: solution of difference equations using z–transforms.

References:

I.N. Sneddon, Integral Transforms, Tata McGraw-Hill, 1974.

P.P. Gupta, Integral Transforms, 2nd Edition, Meerut Publishers, 1989.

MA321 Fundamentals of Data Science (3-0-0) 3

Review of basic Linear Algebra and Probability, Eigenvalues and Eigenvectors, Relationship between SVD and Eigen Decomposition, Extremal Properties of Eigenvalues, Distance between subspaces, Generating Functions for sequences defined by recurrence relationships, The Exponential generating function and the Moment generating function, The Central Limit Theorem, Probability Distributions, Bayes Rule and Estimators, Bounds on Tail Probability, Chernoff Bounds, High-Dimensional Space, Best-Fit Subspaces and Singular Value Decomposition (SVD), Random Walks and Markov Chains, Machine Learning.

References:

Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, 2018.

MA322 Design and Analysis of Algorithms (3-0-0) 3

Models of computation, Algorithm analysis, Time and space complexity, Average and worst case analysis, Lower bounds. Algorithm design techniques: Divide and conquer, Greedy, Dynamic programming, Amortization, Randomization. Problem classes: P, NP, PSPACE; Reducibility, NP-hard and NP-complete problems, Approximation algorithms for some NP-hard problems.

References:

Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms, MIT Press, 3rd Edition, 2009.

Dasgupta, Papadimitrou and Vazirani, Algorithms, McGraw-Hill Education, 2006.

Horowitz, Sahni, and Rajasekaran, Computer Algorithms, Silicon Press, 2007.

Kleinberg and Tardos, Algorithm Design, Pearson, 2005.

Goodrich and Tamassia, Algorithm Design, Wiley, 2001.

MA323 Statistical Methods Lab (0-0-3) 2

Introduction to R, Exploratory data analysis: methods of visualization and summary statistics, Sampling from standard discrete and continuous distributions (Bernoulli, Geometric, Poisson, Gaussian, Gamma), Generic methods for sampling from univariate distributions, The use of R to illustrate probabilistic notions such as conditioning, convolutions and the law of large numbers, Examples of modelling real data (but without formal statistical inference) and the use of

visualizations to assess fit.

MA324 DAA Lab (0-0-3) 2

Design and Implementation of problem solving techniques like divide and conquer, dynamic programming, greedy and graph algorithms.

MA325 Machine Learning (3-0-0) 3

Mathematical preliminaries: Linear algebra and matrix theory; Regression models: Linear regression with single and multiple variables, Logistic regression; Regularization: Handling over-fitting of the data; Artificial Neural networks: perceptron models, back propagation algorithm. Machine learning algorithms for large data sets; Dimensionality reduction: SVD, LDA; Classification: Supervised-Support vector machines, unsupervised-Neighborhood algorithms, k-Means Algorithm Learning theories, Bayesian Learning and Decision Trees, analytical learning, reinforcement learning.

References:

Ethem Alpaydin, Introduction to machine learning, 2nd Edition, PHI publication, 2010.
Tom Mitchell, Machine Learning, McGraw Hill, 1997.
Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

MA326 Theory of Finite Automata, Formal Languages and Computation (3-0-0) 3

Grammars, Production systems, Chomskian Hierarchy, Right linear grammar and Finite state automata, Context free grammars, Normal forms, uvwxy theorem, Parikh mapping, Self-embedding property, Subfamilies of CFL, Derivation trees and ambiguity.

Finite state Automata, Non deterministic and deterministic FSA, NFSA with ε- moves, Regular Expressions, Equivalence of regular expression and FSA.

Pumping lemma, closure properties and decidability, Myhill – Nerode theorem and minimization, Finite automata with output.

Pushdown automata, Acceptance by empty store and final state, Equivalence between pushdown automata and context-free grammars, Closure properties of CFL, Deterministic pushdown automata.

Turing Machines, Techniques for Turing machine construction, Generalized and restricted versions equivalent to the basic model, Godel numbering, Universal Turing Machine, Recursively enumerable sets and recursive sets, Computable functions, time space complexity measures, context sensitive languages and linear bound automata.

Decidability, Post's correspondence problem, Rice's theorem, decidability of membership, emptiness and equivalence problems of languages. Time and tape complexity measures of Turing machines, Random access machines, the classes P and NP, NP-Completeness, satisfiability and Cook's theorem, Polynomial reduction and some NP-complete problems.

References:

John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Introduction to Automata Theory, languages and Computation, 3rd Edition, Pearson, 2008.
Peter linz, Introduction to formal languages and automata, Narosa publishing, 2006.
Michael Sipser, Introduction to the Theory of Computation, Thomson learning, 2001.

MA327 Scientific Computing Lab (0-0-3) 2

Implement a mini project using the concepts studied in preceeding semesters.

MA406 Statistical Design and Analysis of Experiments (3-0-0) 3

Sampling theory: random samples, statistics, sampling distributions, central limit theorem, statistical inference: point estimation, unbiasedness, interval estimation of mean and variance, hypothesis testing, types of errors, one – sided, two – sided tests, tests concerning means and variances, goodness of fit tests, Analysis of variance of one – way, two – way classified data, experimental designs: CRD, RBD, LSD, factorial experiments.

References:

D.C. Montgomery, Design and Analysis of Experiments, 9th Edition, John Wiley, 2017.
R.V. Hogg and A.T. Craig, Introduction to Mathematical Statistics, 5th Edition, McMillan, 1995.

MA421 Financial Mathematics (3-0-0) 3

Basics of financial markets, market efficiency, stock market anomalies, risk-return tradeoff, Markowitz portfolio model, Sharpe ratio, Treanor ratio; Asset pricing models: Capital Asset Pricing Model (CAPM), Arbitrage pricing theory (APT), single and multifactor models (Fama-French multifactor models, Carhart four-factor models, liquidity augmented models etc.), portfolio optimization.

Basics of financial derivatives, mark to market, margin trading, hedging, arbitraging, types of derivative instruments (futures, options), option pricing theory: single and multiperiod binomial pricing models, Cox-Ross-Rubinstein (CRR) model, Black-Scholes formula for option pricing as a limit of CRR model, Greeks, derivative strategy, term structure of interest rates and interest rate derivatives.

References:

Goodman and Stampfli, The Mathematics of Finance: Modeling and Hedging, Brooks/Cole, 2001.

S. E. Shreve, Stochastic Calculus for Finance I and II, Springer Verlag, 2005.

Ales Cerny, Mathematical Techniques in Finance: Tools for incomplete Market, Princeton University Press, 2009.

4. Elective Courses

MA206 Number Theory and Cryptography (3-0-0) 3

Elementary Number Theory Congruences, applications to Factoring. Finite fields, Quadratic residues and reciprocity. Simple cryptosystems, public key cryptography, RSA, Discrete logs. Primality and Factoring, the rho method, Fermat factorization, continued fraction and Quadratic Sieve methods.

References:

N. Kobltiz., A Course in Number Theory and Cryptography, Springer, 1994.

MA405 Reliability Theory and Applications (3-0-0) 3

Reliability-concepts and definitions, causes of failure, concept of hazard, failure models, bathtub curve, MTTF, MTBF, system reliability for various configurations, reliability improvement, redundancy, reliability-cost trade-off, maintainability and availability concepts, system safety analysis, FTA, FMEA.

References:

E.E.Lewis, Introduction to Reliability Engineering, 2nd Edition, John Wiley, 1996.

K.S.Trivedi, Probability and Statistics with Reliability Queuing and Computer Science Applications, 2nd Edition, PHI, 2016.

MA500 Capstone Project 4

(Description to be added)

MA506 Quadratic Forms and Linear Algebra (3-0-0) 3

Review of basics, Singular Value Decomposition, Generalized Inverses, Triangular and Jordan Canonical forms of matrices, Matrix exponential, Inner Product Spaces, Bilinear and Quadratic Forms, Definite and Indefinite Forms, Sylvester's law of inertia, QR Factorization, Best approximation, method of least squares, Maximum principles, finding the largest Eigen value, Rayleigh quotient.

References:

G. Strang, Linear Algebra and its applications, Thomson Learning, 2003.
Peter D Lax, Linear Algebra, Wiley, 2004.
S. Lipschutz & M Lipson, Linear Algebra, Schaum's Outline series, 2005.

MA507 Image Processing (3-0-0) 3

Introduction to image processing, Image acquisition, sampling and quantization, Image transforms: Discrete Fourier transform, Discrete cosine transform, Discrete sine transform and wavelet transform, Image restoration: Image degradation models, blurs and noise models, restoration methods, Weiner filter and regularization filters, Image enhancement: Enhancement in Spatial and frequency domain, unsharp masking and high-boost filtering, Image segmentation: Image thresholding, region based segmentation methods, region growing, region merging & splitting and active contour models, Image Compression : lossy/lossless compression methods, Image Analysis, Introduction to image processing tool box in Matlab, Applications of image processing to various imaging systems.

References:

R.C. Gonzalez, R.E. Woods, Digital image processing using MATLAB, Prentice Hall, 2nd Edition, 2003.
Henri Maitre, Image Processing, 1st Edition, Wiley, 2008.
T.F. Chan, J.H. Shen, Image processing and analysis, SIAM, 1st Edition, 2005.
Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing, Addison-Wesley, 2nd Edition, 2002.
Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1992.

MA508 Soft Computing (3-0-0) 3

Learning and Soft Computing: basic tools of Soft Computing, Learning and Statistical Approaches to Regression and Classification. Neural Networks: Mathematical Models of Neurons, ANN Architecture, Learning Rules, Learning Paradigms – Supervised, Unsupervised, and Reinforced Learning. ANN Training Algorithms. Multi-Layer Perception Model, Hopfield Networks, Associative Memories, Application of Artificial Neural Networks. Fuzzy Logic: Classical and Fuzzy Sets, Membership Function, Fuzzy Rule generation. Operations on Fuzzy sets, Fuzzy Arithmetic, Fuzzy Logic, Uncertainty Based Information: Combination of Operations, Aggregation Operations. Fuzzy numbers, Linguistic variables, Arithmetic Operations on Intervals and Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. Classical Logic, Multi Valued Logic, Fuzzy Propositions, Non Specificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy sets. Neuro-Fuzzy Systems, Applications of Fuzzy Logic in Medicine, Economics, Genetic Algorithms in Problem Solving.

References:

Vojislav Kecman, Learning and Soft Computing, Pearson Education (Asia) PTE, 2004.
Anderson J A, An Introduction to Neural Networks, PHI, 1999.
S Haykin, Neural Networks: A Comprehensive Foundation, Pearson Education, 2003.
Hertz J, Krogh, R. G. Palmer, Introduction to the Theory of Neural Computation, Addition-Wesley, 1991.
G.J. Klir and B Yuan, Fuzzy Sets and Fuzzy Logic, PHI, 2001.
Melanie Mitchell, An Introduction to Genetic Algorithms, PHI, 1998.

MA509 Combinatorial Optimization (3-0-0) 3

Algorithms for optimization of combinatorial optimization problems. Integer Programming and Network Optimization algorithms, combinatorial problems on Graphs or Networks, Polyhedral Combinatorics, Complexity of Problems such as linear programming and the traveling salesman problem. NP-Completeness, approximation algorithms, worst case and probabilistic analysis of algorithms and local search.

References:

C.H. Papadimitriou and K. Steiglitz, Combinatorial Optimization, Algorithms and Complexity, Prentice Hall, 1982.

E. L. Lawler, Combinatorial Optimization – Networks and Matroids, Holt, Rinehart and Winston, 1976.

C. Berge, Principles of Combinatorics, Academic Press, 1971.

Tucker, Applied Combinatorics, 2nd Edition, John Wiley, 1984.

L. R. Ford Jr. and D. R. Fulkerson, Flows in Networks, Princeton, Univ. Press, 1952.

Pardalos, Panos; Du, Ding-Zhu; Graham, Ronald L., Handbook of Combinatorial Optimization, Springer, 2013.

Lex Schrijver, Combinatorial Optimization: Polyhedra and Efficiency, 3-Volume book, Springer-Verlag, 2003.

MA514 Pattern Recognition (3-0-0) 3

Introduction to pattern recognition, Classification, Non-Metric methods, Maximum-Likelihood and Bayesian Parameter Estimation, Supervised learning, Nonparametric Techniques, Linear Discriminant Functions, Feature extraction and selection, Multilayer Neural Networks, Algorithm-Independent Machine Learning, Unsupervised Learning and Clustering, Comparison of classifiers.

References:

Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2001.

Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

Geoff Dougherty, Pattern recognition and classification - An Introduction, Springer, 2013.

MA515 Statistical Techniques for Data Mining (3-0-0) 3

Introduction - Data Preprocessing and representation, Taxonomy for data mining tasks, Predictive modeling, Association rule mining, Cluster analysis, Classification Techniques, Regression analysis, Time series analysis, Bayesian learning, Data warehousing, Multi-Dimensional modeling and analysis, Performance issues and indexing, Development life cycle, Applications of Data Mining.

References:

Jiawei Han, Micheline Kamber, Data Mining - Concepts and Techniques, 3rd Edition, Morgan Kaufmann Publishers, Elsevier, 2012.

Pang-Ning Tam, Michael Seinbach, Anuj Karpatne and Vipin Kumar, Introduction to Data Mining, 2nd Edition, Pearson.

G. James, D. Witten, T. Hastie and R. Tibshirani, An Introduction to Statistical Learning - with applications in R, Springer, 2017.

T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning – Data Mining, Inference and Prediction, 2nd Edition, Springer, 2009.

MA516 Software Engineering (3-0-0) 3

Introduction to software engineering, Generic view of Process, Process models, System Engineering: Business Process Engineering, Product Engineering, Requirements Engineering, Building Analysis model, Design Engineering, Creating an Architectural Design, Modeling component – level Design, Software Testing: Testing strategies, Testing tactics Product metrics, Managing Software Projects: Project management. Metrics for process and projects, Estimation, Projects scheduling, Risk management, Quality management, Change management.

References:

Roger S. Pressman, Software Engineering – A practitioner's Approach, 7th Edition, MacGraw-Hill, 2010.

Ian Sommer ville, Software Engineering, 9th Edition, Addison-Wesley.

Rajib Mall, Fundamentals of Software Engineering, 3rd Edition, Prentice-Hall India (PHI) Learning Pvt Ltd.

MA517 Algorithmic Combinatorics (3-0-0) 3

Fundamental Notions related to Enumerative Combinatorics (Lists/Permutations, Sets/Combinations, Special Bijections, etc.), The Twelve-fold Way of Counting, Integer Partitions, Finite Group Actions, The Cauchy-Frobenius Lemma, Structures and Algorithms, Analysis of Algorithms, Complexity Classes, Integer Partitions, Set Partitions, Bell and Stirling Numbers, Labeled Trees, Catalan Families, Backtracking Algorithms, Permutation Groups.

References:

Donald L. Kreher, Douglas R. Stinson, Combinatorial Algorithms: Generation, Enumeration, and Search, Series: Discrete Mathematics and its applications, CRC Press, 1998.

Tucker A., Applied Combinatorics, 2nd Edition, John Wiley, 1984.

R. Graham, D. Knuth, and O. Patashnik, Concrete Mathematics, Addison-Wesley, 1994.

R. Stanley, Enumerative Combinatorics, Volumes I and II, Cambridge University Press, 2001.

MA518 Selected Topics in Graph Theory (3-0-0) 3

Graphs – An Introduction, Classes of graphs, Distances in graphs, Domination, Labelling, Coloring – Introduction & Types of coloring – Complete Colorings, Colorings and Distance: Coloring, (2,1)-Coloring, Radio Coloring, Hamiltonian Coloring, Critical Concepts, Independence, Matching and Covering, Chordal graphs, Perfect graphs, Interval graphs, Planar graphs, Graph Operations, Graph Partition, Probability on graphs – Random graphs, Hyper graphs, Algebraic concepts in graph theory, IP & LP formulation of selected graph problems, Graph Models.

References:

Douglas B. West, Introduction to Graph Theory, 2nd Edition, PHI Learning Pvt. Ltd., 2002.

Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Fundamentals of Domination in graphs, Marcel Dekker, Inc., New York, 1998.

Gary Chartrand and Ping Zhang, Chromatic Graph Theory, CRC Press, 2009.

Tommy R. Jensen and Bjarne Toft, Graph Coloring problems, John Wiley & sons, 1995.

Michael Stiebitz, Diego Scheide, Bjarne Toft and Lene M. Favrholdt, Graph Edge Coloring, Wiley, 2012.

Béla Bollobás, Random Graphs, 2nd Edition, Cambridge University Press, 2001.

Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Domination in graphs – Advanced Topics, Marcel Dekker, Inc., New York, 1998.

MA519 System Modeling and Simulation (3-0-0) 3

Basic simulation modeling: The nature of simulation, definition of systems, models and simulation, Structure of simulation models, advantages and disadvantages of simulation, steps in a simulation study, Classification of simulation models, Discrete-Event simulation: Selecting Input Probability Distributions, Random number Generators, Generating Random variables for standard distributions, Output Analysis for a single system. System Software: GPSS, general description, facilities, storages, *Queues, transfer blocks, control statements, variable logic switches, Boolean variables, functions, concept of user chains, facility preemption, matching Introduction* to other simulation languages such as MATLAB, TUTSIM Modeling and Simulation of Continuous Systems.

References:

G. Gordon, System Simulation, 2nd Edition, PHI, 1989.

A. M. Law and W. D. Kelton, simulation, modeling and analysis, McGraw Hill.

J. A. Payne, Introduction to simulation, Programming Techniques and methods of analysis.

Thomas J. Schriber, Simulation Using GPSS, John Wiley and Sons.

Mariyansky, Digital Computer and Simulation, CBS Publishers, New Delhi.

MA520 Selected Topics in Computer Algorithms (3-0-0) 3

Computational Geometry: Convex Hull, Polygon triangulation, Voronoi diagram. String processing algorithms: KMP algorithm, Boyer-Moore algorithm. Algebraic and number theoretic algorithms: Modular arithmetic, Chinese remainder theorem. Linear programming and combinatorial optimization: LPP formulation, simplex method, NP-completeness and Approximation, Polynomial time reduction.

References:

De Berg, Mark and Cheong, Otfried and van Kreveld, Marc and Overmars, Mark, Computational geometry, Springer, 2008.

Charras, Christian, and Thierry Lecroq. Handbook of exact string matching algorithms. King's College Publications, 2004.

T.H Cormen, C.E Leiserson, R.L. Rivest, C. Stein, Introduction to algorithms, 3rd Edition, PHI, 2009.

Jon Kleinberg Eva Tardos, Algorithm Design, Pearson, 2006.

MA521 Mobile Computing (3-0-0) 3

Mobility: Issues, challenges, and benefits; Review of mobile and cellular communication technology; Review of distributed/network operating systems, ubiquitous computing. Network Programming: Process communication techniques, remote login, ftp, socket programming, RPC, RMI, client-server programming. Process Migration: Steps, advantages, application taxonomy, alternatives, case study of DEMOS/MP. Mobile Computing: Physical mobility, challenges, limits and connectivity, mobile IP and cellular IP in mobile computing, case study of CODA. Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDA technologies and standards. Mobile Adhoc Networks: Hidden and exposed terminal problems; Routing protocols: DSDV, DSR, AODV. Wireless Sensor Networks: Motes, smart dust, TinyOS, routing protocols. Hand held Devices and OS: Palm, HP; PalmOS, WindowsCE, Windows Mobile. Mobile Internet and WAP: WWW programming model, WAP programming model, gateways. Mobile agents: Aglets, Tcl, PMADE.

References:

Hansman, U. and Merck, L., Principles of Mobile Computing, 2nd Edition, Springer.

Jochen Schiller, Mobile Communications, 2nd Edition, Addison-Wesley, 2004.

Milojicic, D., Douglis, F. and Wheeler R., Mobility Processes, Computers and Agent, Addison Wesley, 2000.

Lange, D. B. and Oshima, M., Programming and Deploying Java Mobile Agents with Aglets, Addison Wesley, 1998.

MA523 Computer Networks (3-0-0) 3

Introduction: Uses of Computer Network, Network hardware, Network software, Hierarchical Reference Models; Physical Layer: The theoretical basis for Data Communication, Transmission media. Wireless transmission, The Telephone system, Data Link Layer: Data Link Layer Design Issues, Error correction and detection, Elementary data link layer protocols, Sliding Window Protocols, Protocol Specification and verification, Medium Access Sublayer: The channel allocation problem, Multiple Access Protocols, IEEE 802 standards for LANs and MANs, Bridges. Network Layer: Network Layer Design issues, Routing algorithms, congestion control algorithms, internet working. Transport Layer: Transport services, transport protocols. Application layer: Application layer protocols, Cryptography.

References:

Jim Kurose and Keith Ross, Computer Networking- Top Down approach, 5th Edition, Pearson Education, 2010.

Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, 5th Edition, Morgan Kaufmann, 2011.

Behrouz A. Forouzan, Data Communications & Networking, 4th Edition, Tata McGraw-Hill Education, 2006.

Douglas E.Comer, The Internet Book, 4th Edition, Prentice Hall, 2007.

MA527 Network Security (3-0-0) 3

Introduction: An Overview of Computer Security, Security Services, Security Mechanisms, Security Attacks, Access Control Matrix, Policy: Security policies, Confidentiality policies, Integrity policies and Hybrid policies. Cryptosystems & Authentication: Classical Cryptography, Substitution Ciphers, permutation Ciphers, Block Ciphers, DES Modes of Operation, AES-Linear Cryptanalysis, Differential Cryptanalysis, Hash Function, SHA 512, Message Authentication Codes, HMAC - Authentication Protocols, Public Key Cryptosystems: Introduction to Public key Cryptography, Number theory, The RSA Cryptosystem and Factoring Integer, Attacks on RSA, The ELGamal Cryptosystem, Digital Signature Algorithm, Finite Fields, Elliptic Curves Cryptography, Key management – Session and Interchange keys, Key exchange and generation, PKI, Digital Signatures**,** Network Security: Secret Sharing Schemes-Kerberos, Pretty Good Privacy (PGP)-Secure Socket Layer (SSL), Intruders – HIDS, NIDS; Firewalls, Viruses

References:

Douglas Stinson, Cryptography Theory and Practice, 2nd Edition, Chapman & Hall/CRC, 2002.

B. A. Forouzan, Cryptography & Network Security, Tata Mc Graw Hill.

W. Stallings, Cryptography and Network Security, 4th Edition, Pearson Education, 2006.

MA529 Advanced Data Science (3-0-0) 3

Algorithms for Massive Data Problems: Streaming, Sketching, and Sampling, Clustering, Random Graphs, Topic Models, Nonnegative Matrix Factorization, Hidden Markov Models, and Graphical Models, An Uncertainty Principle, Linear Programming, The Ellipsoid Algorithm, Integer Optimization, Semi-Definite Programming, Wavelets, The Haar Wavelet, Wavelet Systems, Designing a Wavelet System, Applications.

Reference:

Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, 2018.

MA531 Statistical Quality Control (3-0-0) 3

Sampling theory: random samples, statistic sampling distributions, central limit theorem, concept of Quality, types of variations, process control and product control, control charts for variables and attributes, concept of acceptance sampling, by attributes, O.C., AQL, LTPD, AOQL, ATI etc, types of sampling plans, Reliability, definitions, concept of hazard, bath-tub curve, system reliability for various configurations.

References:

E.L. Grant, Statistical Quality Control, Mc Graw Hill.

D C Montgomery, Introduction to Statistical Quality Control, 4th Edition, John Wiley, 2004.

MA533 Wavelets in Data Science (3-0-0) 3

Introduction: Time - Frequency representation, Fourier and Wavelet bases, what is wavelet and how it is used in Data Science. Theory: From Fourier Transform to Wavelet Transform, How does the Wavelet Transform work?, The different types of Wavelet families, Continuous Wavelet Transform vs Discrete Wavelet Transform, More on Discrete Wavelet Transform: The DWT as a filter-bank. Practical Applications: Visualizing the State-Space using the Continuous Wavelet Transform, Using the Continuous Wavelet Transform and a Convolutional Neural Network to classify signals, Deconstructing a signal using the DWT, Removing (high-frequency) noise using the DWT, Using the Discrete Wavelet Transform to classify signals, Comparison of the classification accuracies between DWT, Fourier Transform and Recurrent Neural Networks. Linear Approximation: Linear Approximation Error, Linear Fourier Approximation, Karhunen - Loeve Approximation

References:

George Bachmann, Lawrence Narici, Edward Beckenstein, Fourier and wavelet analysis, Springer, 2000.

G Mallat, Wavelet tour of signal processing, Academic press.

K P Soman, K I Ramachandran, N G Resmi, Insight into Wavelets: From theory to Practice, Estern economic press.

R. Todd Ogden, Essential wavelets for Statistical Applications And Data Analysis, Springer Science, 1997.

Pedro A. Morettin, Aluísio Pinheiro, Brani Vidakovic, Wavelets in Functional Data Sciences, Springer, 2017.

MA534 Cloud Computing (3-0-0) 3

Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Case Benefits, Risks and Challenges of Cloud Computing, Economic Models and SLAs Topics in Cloud Security; Cloud Infrastructure: Historical Perspective of Data Centers, Datacenter Components: IT equipment and facilities, Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers, Cloud Management and Cloud Software Deployment Considerations; Virtualization: Virtualization (CPU, Memory, I/O); Case Study: Amazon EC2 Software Defined Networks (SDN) Software Defined Storage (SDS); Cloud Storage: Introduction to Storage Systems, Cloud Storage Concepts, Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph); Programming Models: Distributed Programming for the Cloud Data-Parallel Analytics with Hadoop MapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark Graph-Parallel Analytics with GraphLab 2.0 (Power Graph)

References:

Ray J. Rafaels, Cloud Computing: From Beginning to End, Create Space Independent Publishing Platform, 2015.

Michael J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models Wiley, 1st Edition, 2014.

Thomas Erl, Zaigham Mahmood, and Ricardo Puttini. Cloud Computing: Concepts, Technology and Architecture, Prentice Hall, 1st Edition, 2013.

Dan Marinescu, Cloud Computing:Theory and Practice, Morgan Kaufmann, 2nd Edition, 2017.

Tom White, Hadoop:The Definitive Guide , O'Reilly Media, 2009.

MA535 Distributed Computing Systems (3-0-0) 3

Introduction: Computer Networks and Multi-processor systems, Evolution of modern operating systems, Design Goals, transparencies and fundamental issues in Distributed systems, Temporal ordering of events, Global state detection, Physical clocks, Mutual Exclusion Algorithms, Interprocess Communication, Deadlocks in distributed systems, Load balancing techniques, Distributed databases. Security in distributed systems.

References:

Shivarathi & Shingal, Advanced Operating Systems, 1994.

Randy Chow, Distributed Operating Systems and Algorithms.

George Couloris et al, Distributed Systems - concepts and design, Pearson Education, 2002.

A.S. Tanenbaum and M.V. Steen, Distributed Systems - Principles and Paradigms, Pearson Education 2003.

Wolfgang Emmerich, Engineering Distributed Objects, Wiley, 2000.

Gerald Tel, Introduction to Distributed Algorithms, 2nd Edition, Cambridge, 2004.

MA536 Advanced Database Systems (3-0-0) 3

Basic concepts, Architecture for data sharing, Federated DBMS, Distributed databases, Client/server architecture, Multimedia databases, Object oriented databases, Data mining and knowledge discovery, Pattern clustering abstraction and similarity, Clustering for data mining, Data mining using neural networks and genetic algorithms, Discovery of association rules, Frequent episodes in event sequences, Applications of data mining.

References:

Ramez Elmasri, Shamkant B Navathe, Fundamentals of Database Systems, Addison Wesley, 2000.

Stefano Ceri & Giuesppe Pelagatti, Distributed Databases - Principles and Systems, McGraw Hill 1987.

MA537 Optimization Techniques (3-0-0) 3

Introduction and formulation of models, Simplex method, Duality in LP, Dual Simplex Method, Sensitivity Analysis, Transportation problems and Assignment problems, Integer Programming, Classical Optimization Methods, Lagrangian Multipliers and Kuhn – Tucker conditions, Quadratic programming, Basic non-linear programming problems.

References:

H. A.Taha, Operations Research - An Introduction, 8th Edition, PHI, 2007.

F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8th Edition, TMH, 2010.

S. S. Rao, Engineering Optimization: Theory and practice, New Age International publishers.

Open Electives (OE)

MA201 Concrete Mathematics (3-0-0) 3

Sums and Recurrences, General methods, Finite and infinite calculus, Floors and ceilings, Applications, Number theory, Congruences, Chinese remainder Theorem, Generating functions, Solving recurrences, Special generating functions, Convolutions and Exponential generating functions.

References:

G. Knuth, and Patashnik, Concrete Mathematics: A foundation for Computer Science, Pearson, 2000.

MA401 Computational Fluid Dynamics (3-0-0) 3

Philosophy of CFD, Governing Equations of Fluid Dynamics - Derivation, Physical Interpretation, Forms of Governing Equations suitable to CFD, Mathematical behavior of Partial differential Equations, Finite differences, Error & Stability Analysis of numerical schemes, Grid generation with appropriate transformations, CFD techniques - Lax – Wendroff technique, MacCormack's technique. Numerical Solutions to some one and two -dimensional flows.

References:

J. Anderson, Computational fluid dynamics: The basics with applications, International 6th Edition, McGraw Hill, 1995.

C.A.J. Fletcher, Computational techniques for fluid dynamics vol 1& 2, Springer – Verlag.

H.K. Versteeg, W Malalasekera, An Introduction to Computational Fluid Dynamics, 2nd Edition, Longman Scientific & Technical, 2007.

MA403 Mathematical Modeling (3-0-0) 3

Introduction: Mathematical modeling through ordinary differential equations and systems of ordinary differential equations of first order, Mathematical modeling through difference equations, Modeling using partial differential equations, Mathematical modeling through graphs.

References:

J.N. Kapoor, Mathematical Modeling, Wiley Eastern, 1988.

R. Aris, Mathematical Modeling Techniques, Pitman, 1978.

MA408 Stochastic Analysis and Applications (3-0-0) 3

Stochastic processes, basic concepts, classifications, Markov chains, C– K equations, ergodic chains, steady state behavior, Poisson process, derivations, birth and death process, Queuing systems, basic concepts, M|M|1 and M|M|s queues, Reliability, definitions, concept of hazard, bath-tub curve, system reliability for various configurations.

References:

J. Medhi, Stochastic Processes, 2nd Edition, New Age International Publishers, 2002.

K S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI, 2013.

MA512 Numerical Solutions of Differential Equations (3-0-0) 3

Ordinary differential equations: Numerical methods- error analysis, stability and convergence. Euler and Runge-Kutta methods, multistep methods, Adams-Bashforth and Adams-Moulton methods, Gear's open and closed methods, predictor-corrector methods. Stiff Differential equations, Difference methods for boundary value problems. Partial differential equations: classification, elliptic, parabolic and hyperbolic PDEs, Dirichlet, Neumann and mixed boundary conditions. Numerical solution of PDEs: Finite Difference Methods for parabolic, elliptic and hyperbolic PDEs. Finite difference time domain method. Introduction to Finite Element Method - method of weighted residuals.

References:

R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition, Brooks/Cole, 2011.

Jain M. K., Numerical Solution of Differential Equations, 2nd Edition, Wiley Eastern, 1984.

Smith G.D., Numerical Solution of Partial Differential Equations, 3rd Edition, Clarendan Press, 2004.

Patanker S. V., Numerical Heat Transfer and Fluid Flow, McGraw Hill.
R. J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM, 2007.

MA513 Modern Algebra (3-0-0) 3

Groups - Permutation groups, Sylow theorems, solvable groups, Direct products of groups and finite abelian groups. Rings: Ideals, Euclidean and Principal ideal rings, Unique factorization domains and Polynomial rings. Fields: Extension fields, Prime fields, Algebraic and Transcendental extensions. Roots of polynomials, splitting fields, finite fields, Separable and inseparable extensions: Galois Theory, solvability of polynomials by radicals and Abel's theorem.

References:

I.N. Herstein, Topics in Algebra, Wiley casten Ltd.
J.B.Fraleigh; A first course in Abstract algebra, Narera publishers.
N.S. Gopalakrishnan, University Algebra, Vikas publishing House Pvt. Ltd.

MA525 Computational Number Theory (3-0-0) 3

Elementary Number Theory: Theory of Divisibility, Diophantine Equations, Arithmetic Functions, Congruences, Arithmetic of Elliptic Curves. Computational Number Theory: Introduction, Algorithms for Primality Testing, Integer Factorization, Discrete Logarithms. Quantum Number Theoretic Algorithm, Miscellaneous Algorithms in Number Theory, Cryptography and Information Security.

References:

Song Y. Yan, Number Theory for Computing, 2nd Edition. Springer, 2002.
Richard Crandall and Carl Pomerance, Prime numbers: a Computational perspective, Springer, 2001.
Henri Cohen, A course in Computational Algebraic Number Theory, Springer, 2000.

MA526 Game Theory (3-0-0) 3

Introduction: Definition of Games. Actions, Strategies, Preferences, Payoffs, Examples, Strategic Form Games: Strategic form games and examples: Prisoner's Dilemma, Bach or Stravinsky. Dominant Strategy Equilibrium:Strongly dominant strategies, weakly dominant strategies, dominant strategy equilibrium; Examples of Prisoner’s Dilemma and Vickrey Auction, Two Player Zero Sum Games (Matrix Games): Max minimization and Min maximization, Saddle points, Nash equilibrium in matrix games, Minimax theorem, Solution via linear programming & Examples, Bayesian Games: Motivational Examples, Definition of a Bayesian Game and Bayesian Nash Equilibrium and examples.

References:

Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003.
Y. Narahari, Game Theory and Mechanism Design, IISc Press and World Scientific, 2014.
Philip D. Straffin, Jr. Game Theory and Strategy, The Mathematical Association of America, January 1993.
Ken Binmore, Fun and Games: A Text On Game Theory, D. C. Heath & Company, 1992.

MA528 Introduction to Parallel Programming (3-0-0) 3

Computer organization, Memory hierarchy, cache memory, Parallelization Principles: motivation, challenges, metrics, parallelization steps, data distribution, PRAM model; concurrent data structures, and cloud computing systems. Parallel Programming Models and Languages: OpenMP, MPI, CUDA; Distributed Computing: Commodity cluster and cloud computing; Distributed Programming: MapReduce/Hadoop model.

References:

David Culler, Jaswant Singh, Parallel Computing Architecture. A Hardware/Software Approach, Morgan Kauffman. ISBN: 981-4033-103, 1999.

Michael J. Quinn, Parallel Computing. Theory and Practice, Tata: McGraw-Hill. ISBN: 0-07-049546-7, 2002.

Bryant and O'Hallaron, Computer Systems – A Programmer's Perspective, Pearson Education. ISBN: 81-297-0026-3, 2003.

Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Addison Wesley. ISBN: 0-201-64865-2, 2003.

Peter S Pacheco, An introduction to Parallel Programming, Morgan Kauffman. ISBN: 978-93-80931-75-3, 2011.

Online references for Open MP, MPI, CUDA.

MA532 Big Data Analytics (3-0-0) 3

Introduction to Big Data Analytics, Big Data Analytics Platforms, Big Data Storage and Processing, Big Data Analytics Algorithms, Linked Big Data Analysis - Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics.

References:

Michael Minelli, Michele Chambers, Ambiga Dhiraj, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Wiley CIO, 2013.

David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, Morgan Kaufmann, 2013.

Mike Barlow, Real-Time Big Data Analytics: Emerging Architecture, [Kindle Ed.], O'Reilly Media, 2012.

MA538 Artificial Intelligence (3-0-0) 3

Foundation and history of AI, AI Problems and techniques, Heuristic search techniques, Knowledge representation, Reasoning under uncertainty, Planning and learning, Genetic algorithms, Applications of AI, Principles of natural language processing, Expert systems, Current trends in intelligent systems, AI programming languages, Introduction to LISP and PROLOG.

References:

Elain Rich and Kevin Knight, Artificial Intelligence, Tata McGraw Hill Publishing Company Limited, 1995.

Stuart Russel and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 1995.

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