Department of MACS
NITK Surathkal
Curriculum revision

M.Tech in
Computational and Data Science

Academic year 2019 – 2020 onwards

Department of MACS
NITK Surathkal
Curriculum revision of M.Tech Programme

1. **Preamble:**
   The department of MACS is currently offering an M.Tech in Computational Mathematics, which was introduced in July 2014. A review of the course was suggested after two years of its inception. In view of this and considering the feedback from students, alumni and industries, a new programme is proposed as a replacement for the current M.Tech in Computational Mathematics.

2. **Introduction:** There is a clear perception from the corporates today that post graduates with specialized skills in Data Sciences are very essential and vital to run their business smoothly, efficiently and effectively. Further, there is lot of scope for research in this direction. Therefore, the Department of M.A.C.S. strongly feels that it is the right time to restructure the current M.Tech. Programme. The title of the proposed program is M.Tech in Computational and Data Science (CDS)

3. **Purpose and scope of the programme:** The programme is proposed to be reoriented keeping in view the expertise available in the department and the needs of the industry.

4. **Eligibility:** BE /B Tech/M Sc/MCA/Four year B.S. or equivalent in any discipline of science/engineering (with a valid GATE Score). A Strong Mathematical and Programming background is desirable.

5. **Title of the proposed programme:** M.Tech in Computational and Data Science (CDS)

6. **Admission intake:** 29 (Same as the present)

7. **Credit Structure:** Based on the common institute guidelines for PG programmes, the following credit structure is proposed.

Category	**Credits**	**Guidelines**
Programme Core (Pc)	23	>=20
Elective (Ele)	12	>=12
Mandatory Learning Course (MLC)	04	=4
Major Project (MP)	12	8 to 12
Total	**51**	**50 to 55**

Overall Program structure:

Sl.No	**Semester 1**	**Semester 2**	**Semester 3**	**Semester 4**
1	MA721 Programme core 1	MA725 Programme core 5	MA890 Seminar –MLC	MA899 Major project- Phase 2 (8 Credits)
2	MA722 Programme core 2	MA726 Programme core 6	MA891 Minor Project *	
3	MA723 Programme core 3	Elective 2		
4	MA724 Programme core 4	Elective 3	MA898 Major Project -Phase 1 (4 Credits)	
5	Elective 1	Elective 4		

*Minor project to be completed in summer semester.

Semester 1:

Sl. No	Course	Credits
1	MA721 Introduction to Scalable Systems	(3-0-2) 4
2	MA722 Data Structures and Algorithms	(3-0-2) 4
3	MA723 Introduction to Data Science	(3-1-0) 4
4	MA724 Probability, Statistics and Stochastic Processes	(3-0-0) 3
5	Elective1:	(3-0-0) 3

Semester 2:

Sl. No	Course	Credits
1	MA725 Numerical Methods	(3-1-0) 4
2	MA726 Machine Learning	(3-0-2) 4
3	Elective 2:	(3-0-0) 3
4	Elective 3:	(3-0-0) 3
5	Elective 4:	(3-0-0) 3

Semester 3:

Sl. No	Course	Credits
1	MA890 Seminar -MLC	2
2	MA891 Minor Project (To be carried out in summer semester) -MLC	2
3	MA898 Major Project -Phase 1	4

Semester 4:

Sl. No	Course	Credits
1	MA899 Major Project -Phase 2	8

M.Tech in Computational and Data Science (CDS)

Suggested Plan of Study

Sl. No	Semester			
	I	II	III	IV
1	MA721	MA725	MA890	MA899
2	MA722	MA726	MA891	
3	MA723	Elective 2	MA898	
4	MA724	Elective 3		
5	Elective 1	Elective 4		

Credit Requirements:

Category	Minimum Credits to be Earned
Programme Core(Pc)	23
Elective Courses (Ele)	12
Mandatory Learning Courses (MLC)	04
Major Project (MP)	12
Total	**51**

Programme Core (Pc)

MA721	Introduction to Scalable Systems	(3-0-2) 4
MA722	Data Structures and Algorithms	(3-0-2) 4
MA723	Introduction to Data Science	(3-1-0) 4
MA724	Probability, Statistics and Stochastic Processes	(3-0-0) 3
MA725	Numerical Methods	(3-1-0) 4
MA726	Machine Learning	(3-0-2) 4

Elective (Ele) Courses:

MA841	Cloud Computing	(3-0-0) 3
MA842	Distributed Computing Systems	(3-0-0) 3
MA843	Advanced Database Systems	(3-0-0) 3
MA844	Advanced Data Science	(3-0-0) 3
MA845	Computational Linear Algebra	(3-0-0) 3
MA846	Image Processing	(3-0-0) 3
MA847	Soft Computing	(3-0-0) 3
MA848	Combinatorial Optimization	(3-0-0) 3
MA849	Number Theory and Cryptography	(3-0-0) 3
MA850	Mathematical Modeling	(3-0-0) 3
MA851	Numerical Solutions of Differential Equations	(3-0-0) 3
MA852	Optimization Techniques	(3-0-0) 3
MA853	Pattern Recognition	(3-0-0) 3
MA854	Statistical Techniques for Data Mining	(3-0-0) 3
MA855	Big Data Analytics	(3-0-0) 3
MA856	Computer Networks	(3-0-0) 3
MA857	Software Engineering	(3-0-0) 3
MA858	Algorithmic Combinatorics	(3-0-0) 3
MA859	Selected Topics in Graph Theory	(3-0-0) 3
MA860	Systems Modeling and Simulation	(3-0-0) 3
MA861	Selected Topics in Computer Algorithms	(3-0-0) 3
MA862	Mobile Computing	(3-0-0) 3
MA863	Computational Fluid Dynamics	(3-0-0) 3
MA864	Design and Analysis of Experiments	(3-0-0) 3
MA865	Reliability Theory and Applications	(3-0-0) 3
MA866	Computational Number Theory	(3-0-0) 3
MA867	Game Theory	(3-0-0) 3
MA868	Theory of Computation	(3-0-0) 3
MA869	Network Security	(3-0-0) 3

Mandatory Learning Courses (MLC)

MA890	Seminar	2
MA891	Practical Training/ Minor Project	2

Major Project (MP)

MA898	Major Project -Phase 1	4
MA899	Major Project -Phase 2	8

Course Contents:

Programme core (Pc):

MA721 Introduction to Scalable Systems (3-0-2) 4

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:

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

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

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

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

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

Online references for OpenMP, MPI, CUDA

MA722 Data Structures and Algorithms (3-0-2) 4

Introduction: Fundamental data structures, The role of algorithms in computing, Asymptotic notations and analysis of the growth of the functions. Divide and Conquer methods and Solving recurrences : Sorting and searching methods Linear and non linear data structures: Arrays, Lists, Stacks, Queues, Trees and Graphs, Graph Algorithms: Single Source Shortest path, All pair shortest path, minimum cost spanning trees, Special matrices and their representations: Sparse, circulant, toeplitz etc.

References:

T.H Cormen, C.E Leiserson, R.L. Rivest, C. Stein, Introduction To
Algorithms, Third edition, PHI, 2009.

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

Michael T. Goodrich, Robert Tamassia, Algorithm Design, John Wiley& Sons, 2006.

Sartas Sahni, Fundamentals of computer algorithms, Pearson

Donald E. Knutrh, Art of Computer Programming, Volume 1-3, 3rd edition.

MA723 Introduction to Data Science (3-1-0) 4

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,.

Reference:

Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, 2018 (available online)

MA724 Probability, Statistics and Stochastic Processes (3-0-0) 3

Overview of probability, random variables, probability functions, expectation, variance, correlation coefficient, some important probability distributions; correlation and regression of bivariate data, least square method, simple linear regression, multiple and partial correlations, multiple linear regression, partial regression coefficients, standard error of estimates; stochastic process, classification, Markov chains, C-K equations, ergodic chains, steady state behavior, Poisson process, birth and death process, queuing theory, basic concepts, M/M/1 and M/M/s queues.

References:

W.W.Hines and D.C.Montgomery, Probability and statistics in engineering and management science, John Wiley.

J.Medhi, Statistical methods, New age international publishers

J.Medhi, Stochastic processes, New age international publishers

MA725 Numerical Methods (3-1-0) 4

Root finding (zeros of a function) of polynomials 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

MA726 Machine Learning (3-0-2) 4

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", second edition, PHI publication, 2010.
Tom Mitchell, "Machine Learning", McGraw Hill, 1997
Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

Programme Electives:

MA841 Cloud Computing (3-0-0) 3

Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Cases Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs Topics in Cloud Security; Cloud Infrastructur :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 (PowerGraph)

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.

MA842 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
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, 2/e, Cambridge, 2004.

MA843 Advanced Database Systems (3-0-0) 3

Basic concepts. Architecture for data sharing, Federated DBMS. Distributed databases. Client/server architecture. Multi-media databases. Object oriented data bases. 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.

MA844 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 (available online)

MA845 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 LDM^T and LDL^T factorizations, positive definite systems, banded systems, symmetric indefinite systems, block systems, vandermonde systems and the FFT, Toeplitz and related systems.

References:

Gene H. Golub nad Charles F. Van Loan, Matrix Computations, Third Ed, Hindustan book agency, 2007.

A.R. Gourlay and G.A. Watson, Computational methods for matrix eigenproblems, 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 Mathlab, Prentice-Hall, Upper Saddle River, N.J, 1997.

MA846 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, Second edition, 2003.

Henri Maitre, "Image Processing",first edition, Wiley, 2008.

T.F. Chan, J.H. Shen, "Image processing and analysis", SIAM,First 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.

MA847 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

MA848 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, 2 nd edn, 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

MA849 Number Theory and Cryptography (3-0-0) 3

Elementary Number Theory Congruences, applications to Factoring. Finite fields, Quadratic residiues 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. Koblitz., A Course in Number Theory and Cryptography, Springer, 1994.

MA850 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.

MA851 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 Edn, Brooks/Cole.
Jain M. K., Numerical Solution of Differential Equations, Wiley Eastern
Smith G.D., Numerical Solution of Partial Differential Equations, Clarendan Press
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.

MA852 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, 8thedition,2007,PHI.
F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8th edition, 2010, TMH.
S S Rao Engineering Optimization: Theory and practice, Newage International publishers.

MA853 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.

MA854 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, Third Edition, Morgan Kaufmann Publishers, Elsevier.
Pang-Ning Tam, Michael Seinbach, Anuj Karpatne and Vipin Kumar, Introduction to Data Mining, Second Edition, Pearson.
G. James, D. Witten, T. Hastie and R. Tibshirani, An Introduction to Statistical Learning - with applications in R, Springer.
T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning – Data Mining, Inference and Prediction, Second edition, Springer.

MA855 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 [2013], "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley CIO.
David Loshin [2013], "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann.
Mike Barlow [2012], " Real-Time Big Data Analytics: Emerging Architecture", [Kindle Ed.], O'Reilly Media.

MA856 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, 5 th edition, Pearson Education, 2010
Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, 5 th edition, Morgan Kaufmann, 2011
Behrouz A. Forouzan, Data Communications & Networking, 4 th edition, Tata McGraw-Hill Education, 2006
Douglas E.Comer, The Internet Book, 4 th edition, Prentice Hall, 2007

MA857 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, 7 th Edn, MacGraw-Hill
Ian Sommer ville, Software Engineering, 9 th Edn, Addison-Wesley
Rajib Mall, Fundamentals of Software Engineering, 3 rd Edn, Prentice-Hall India(PHI) Learning Pvt Ltd.

MA858 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, 2 nd edn, John Wiley, 1984
R. Graham, D. Knuth, and O. Patashnik, Concrete Mathematics,Addison-Wesley, 1994
R. Stanley, Enumerative Combinatorics, Volumes I and II, Cambridge UniversityPress, 2001

MA859 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, 2 nd Edition, PHI Learning Pvt. Ltd., 2012.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Fundamental of Domination in graphs, Marcel Dekker, Inc.,New York 1998.
Gary Chartrand and Ping Zhang, Chromatic Graph Theory, CRC Press.
Tommy R. Jensen and Bjarne Toft, Graph Coloring problems, John Wiley & sons.
Michael Stiebitz, Diego Scheide, Bjarne Toft and Lene M. Favrholdt, Graph Edge Coloring, Wiley.
Random Graphs – Béla Bollobás, 2 nd Edition, Cambridge University Press.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Domination in graphs – Advanced Topics, Marcel Dekker, Inc.,New York 1998.

MA860 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,SystemSimulation,PHI.
A. M.LawandW.D.Kelton,simulation,modelingandanalysis,McGrawHill.
J.A.Payne,Introductionto simulation,ProgrammingTechniquesandmethodsofanalysis.
ThomasJ. Schriber,SimulationUsingGPSS,JohnWileyandSons.
Mariyansky,DigitalComputerandSimulation,CBSPublishers,NewDelhi.

MA861 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 theory. Linear programming and combinatorial optimization: LPP formulation, simplex method NP-completeness and Approximation: Polynomial time reduction, NP-complete proofs

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, Third edition, PHI, 2009.
Jon Kleinberg Eva Tardos, Algorithm Design, Pearson, 2006

MA862 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 andconnectivity, mobile IP and cellular IP in mobile computing, case studyof CODA. Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDAtechnologies 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, second 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 JavaMobile Agents with Aglets, Addison Wesley. 1998

MA863 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, McGraw Hill.
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, Longman Scientific & Technical.

MA864 Design and Analysis of Experiments (3-0-0) 3

Introduction to probability, one-dimensional random variables, two and higher dimensional random variables, probability

distributions, Sampling theory, moments, mgf and their properties, parameter estimation, point estimation, interval estimation of means and variances, Hypothesis testing, Goodness of fit tests, analysis of variance of one- way and two-way classified data, experimental design.

References:

Douglas Montogomery, Design andAnalysis of Experiments, John Wiley
Sheldon M. Ross,IntroductiontoProbabilityandStatistics forEngineersandScientists,John Wiley
Hogg R.V., & Craig A.T.,Introduction to MathematicalStatistics,McMillan

MA865 Reliability Theory and Applications (3-0-0) 3

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

References:

E.E.Lewis, Introduction to Reliability Engineering, JohnWiley.
KS.Trivedi,Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI.

MA866 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 Ed. 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.

MA867 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.

MA868 Theory of Computation (3-0-0) 3

Introduction, Abstract Models for Computation and their relationship with formal languages and Theory of Recursive Functions; Computational and Representational System Models: Finite Automata; Push-down Automata; Linear Bounded Automata; Turing Machines; Formal Language Models; Regular Expressions, Context free Languages, Context Sensitive Languages, Recursively, Enumerable Languages, Generative Grammars, Recognition Procedures; Finite Representation for formal languages, Chomsky Hierarchy; Normal Forms; Derivation Graphs; Pumping Lemma; Undecidability; Recursive Functions and Computability; Computational Effectiveness, Complexity Measures, Reducibility; Complexity Classes.

References:

Hopcroft and Ullman, Introduction to Automata Theory; Languages and Computation, Narosa. Gyorgy E. Revesz, Introdution to Formal Languages, Dover. Aho, Hopcraft & Ullman, Automata, Languages and Computation, Narosa, 1986. Mishra and Chandrashekar, Theory of Computer Science, Prentice Hall of India, 1999.

MA869 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.
B. A. Forouzan, "Cryptography & Network Security", Tata Mc Graw Hill.
W. Stallings, "Cryptography and Network Security", Pearson Education.