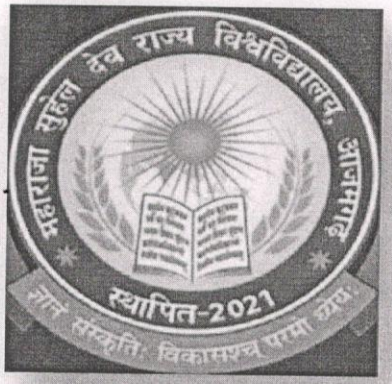
M. S. D. State University, Azamgarh



Academic Summary for Department

The main focus of the department is to innovate and integrate computational and analytical research approaches adopted in different branches of sciences to find solutions to the complex problems. Rapid advancement in different field of sciences (such as physics, mathematics, statistics and biology) and the cutting edge technologies are enabling the research on a tremendous pace worldwide which is providing opportunity for innovations in sciences.

On line System

(Ravidutt Sharma) Gurugram 04.11.2023
Online Mode.
4/11/23 (T. Ahmad) (Abdullah) (Mirza Faish Beg)

Manoj Kr. Singh
BHU, Varsi

Sazad Mirza
DOC, GKP.

(Prof. Mohd. Sadiq Khan)

Semester Courses of M.Sc. (Integrative Science)

Syllabus

COURSE OBJECTIVE:

1. To insulate the students from fast obsolescence of by way of imparting fundamental knowledge,thinking skills and technical skills for superior mastery in the areas of Integrative Science and its applications,
2.
3. Enable the students to be well placed in leading business organizations anywhere in the world.

COURSE DURATION: The course duration is of 24 months spread over four Semesters with credit hours as per the norms. The course has sufficient emphasis on, integrative biology, statistical and mathematical modelling, physical sciences and computing skills.

COURSE CURRICULUM PLAN: The Course Curriculum is based on comparative analysis of existing MSc Integrative Science curriculums of other Universities including national and International. The curriculum has sufficient exposure to hands-on skills and is much more directed towards higher employability. It is also well suited for upward accommodation of science graduates from any stream.

Similar course that are running in Universities: Jawaharlal Nehru University (JNU), New Delhi, Mogran State University, Baltimore, University of Colorado, Denver

Summary

Semester No	Contact hr/wk	Credit
1	24	25
2	35	25
3	31	25
4	41	25
Total	**131**	**100**

Detailed Course structure

Semester - I

A. THEORY							
S.NO.	**CODE**	**THEORY**	**CONTACTS PERIODS/WEEK**				**CREDITS**
			L	**T**	**P**	**TOTAL**	
1	MIS101	Fundamentals of Mathematics	3	1	-	3	3
2	MIS102	Introduction to Probability and Statistics	3	1	-	3	3
3	MIS103	Programming Fundamentals and Data Structure	4	1	-	3	4
4	MIS104	Fundamentals of Bioinformatics	3	1	-	3	3
5	MIS105	Advances in Operating system with Unix	3	1	-	3	3
		Total of Theory				**15**	**16**
B. PRACTICAL (Practical Lab-1) (Choose Anyone)							
6	MIS191	Programming in Python	-	1	3	3	3
7	MIS192	Programming in R	-	1	3	3	3
		Total of Practical				**3**	**3**
C. Elective – 1 (Any two of the following)							
8	MIS E101	Fundamentals of Physical Sciences	3	1	-	3	3
9	MIS E102	Fundamentals of Biological Sciences	3	1	-	3	3
10	MIS E103	Fundamentals of database management system	3	1	-	3	3
		Total of Elective				**6**	**6**
Total of Semester			**24**				**25**

Semester - II

A. THEORY							
SL. NO.	**CODE**	**THEORY**	**CONTACTS PERIODS/WEEK**				**CREDITS**
			L	**T**	**P**	**TOTAL**	
1	MIS201	Mathematical modelling in biology	3	1	-	4	3
2	MIS202	Advances statistics and Linear Algebra	3	1	-	4	3
3	MIS203	Graphs and Networks for complex system	2	1	1	5	3
4	MIS204	Numerical Techniques and Programming	3	1	-	4	3
5	MIS205	Omics Sciences	3	-	-	3	3
6	MIS206	Computational Structural Biology	2	1	1	5	3
					Total of Theory	**26**	**18**
B. PRACTICAL (Practical Lab-2)							
7	MIS291	Laboratory-II (Mathematical Modelling, Computational Structural Biology)	-	-	4	4	4
					Total of Practical	**4**	**4**
C. Elective – II (Any one of the following)							
8	MIS E201	Biological Sequence Analysis	2	1	1	5	3
9	MIS E202	Working with MySQL	2	1	1	5	3
10	MIS E203	Chemoinformatics in drug designing	2	1	1	5	3
					Total of Elective	**5**	**3**
Total of Semester			**35**				**25**

Semester - III

A. THEORY							
S. NO.	**CODE**	**THEORY**	**CONTACTS PERIODS/WEEK**				**CREDITS**
			L	**T**	**P**	**TOTAL**	
1	MIS301	Research Methodology	3	1	-	3	3
2	MIS302	Data Mining and Modeling	3	1	-	3	3
3	MIS303	Systems Biology	3	1	-	3	3
4	MIS304	Biomolecular simulation theory and application	3	1	-	3	3
5	MIS 305	Non-linear Dynamics	3	1	-	3	3
6	MIS 306	Data Science and Machine Learning	3	1	-	3	3
		Total of Theory				**18**	**18**
B. PRACTICAL (Practical Lab-3)							
7	MIS391	Laboratory-III (System Biology, Data Mining, Biomolecular Simulation)	-	-	2	4	2
8	MIS395	Summer Training or short project	-	-	4	4	2
		Total of Practical				**8**	**4**
C. Elective – III (Any one of the following)							
9	MIS E301A	Analysis of Next generation sequencing Data	2	1	1	5	3
10	MIS E301B	Database advance (NoSQL Databases)	2	1	1	5	3
11	MIS E301C	Soft Computing and optimization techniques	2	1	1	5	3
		Total of Elective				**5**	**3**
Total of Semester						**31**	**25**

Semester - IV

A. THEORY							
SL. NO	**CODE**	**THEORY**	**CONTACTS PERIODS/WEEK**				**CREDITS**
			L	**T**	**P**	**TOTAL**	
1	MIS401	Artificial and deep Neural network	3	1	1	6	4
					Total of Theory	**6**	**4**
B. PRACTICAL (Practical Lab-4)							
2	MIS 491	Seminar	-	-	-	2	1
3	MIS492	Term paper	-	-	-	2	1
4	MIS493	Dissertation	-	-	-	15	15
					Total of Practical	**27**	**17**
C. Elective –IV (Any two of the following)							
5	MIS E401	Deployment of application with Distributed and Cloud computing Application	1	1	1	4	2
6	MIS E402	Integration of Blockchain Technology	1	1	1	4	2
7	MIS E403	AI in Health Sciences (AI integration with biological data using Deepvariant, alphafold, crispercas to target cut site etc)	1	1	1	4	2
8	MIS E404	Bigdata Tools and Technology	1	1	1	4	2
9	MIS E405	Quantum Computing	1	1	1	4	2
					Total of Elective	**8**	**4**
Total of Semester					**41**		**25**

* Practical based on the theory syllabus shall commenced for those subject that are inclusive of practical credits.

MIS101 Fundamentals of Mathematics

Calculus, Differentiation integration. Differential equation, Euclidean vector spaces, Eigenvalues and eigenvectors Linear transformations, Projections, Mathematical operations with matrices (i.e. addition, multiplication), Matrix inverses and determinants, Orthogonal matrices, Positive-definite matrices

Text & References:

- Calculus by Apostol
- Calculus by H. Anton, I. Bivens and S. Davis,
- Calculus by M. J. Strauss, G. L. Bradley and K. J. Smith
- Principles of mathematical analysis by Rudin
- Real Analysis by Royden http://entrance-exam.net/reference-books-for-delhi-university-msc-in-mathematics-entrance-exam/
- S.Lang: Algebra 3rd Edition, Addison-Wesley,1993
- M.Artin: Algebra, Prentice-Hall Of India,1991
- N.Jacobson:Basic Algebra,Volumes 1&2,W.H.Freeman,1980
- Goon. A.M., Gupta. M.k. and Das Gupta. B(1999)Fundamental of Statistics, Vol.2, world Press, Calcutta.
- Cambridge University Press, Indian edition,1997
- P.B.Bhattacharya, S.K.Jain and S.R. Nagpaul: Basic Abstract Algebra(2nd Edition).
- Misra. B.D(1982): An Introduction to the study of Population, South Asian Publishing.
- A Differential Equation Approach Using Maple by Taylor and Francis
- Mathematical Modelling with Case Studies by Belinda Barnes and Glenn R. Fulford
- Differential Equations and Boundary Value Problems: Computing and Modelling by C. H. Edwards and D. E. Penny

MIS102 Introduction to Statistics

Descriptive Statistics Statistics: Preliminary concepts; Measures of Central Tendency: Mean, Median, Mode Measures of Dispersion: Range, Standard deviation, Variance, Covariance, Graphical Representation of Statistics: Histograms, Bar plots, Scatter plots etc.

Probability Random Experiments, Trial and Event, Sample Space, Mutually Exclusive or Disjoint Events, Mutually Exhaustive Events, Equally Probable Events, Complementary Event, Classical definition of Probability, Statistical definition of Probability, Axiomatic definition of Probability, Addition theorem, Multiplication theorem, Conditional Probability, Bayes' Theorem. Expectation.

Continuous Distribution Normal Distribution, Properties of Normal distribution

Correlation Bivariate distribution Correlation, Types of Correlation, Simple Correlation Coefficient for ungrouped data, Properties and Interpretation of Correlation Coefficient, Coefficient of determination, Scatter diagram, Standard Error, Probable error of Correlation Coefficient. Rank correlation, Some examples.

Introduction to the Inferential Statistics Parameter, Statistic, Null hypothesis, Alternative hypothesis, Critical region, Type1 Error, Type 11 Error, Level of significance, P-value and its applications. **Test of Significance for Small samples:** One sample t-test, Paired t-test, Degrees of freedom for t-test, F test for equality of Population variances, Degrees of freedom for F-test. Test of Significance for Large samples: Normal

test for sample mean and population mean, Normal test for two sample means. Chi-square Test: Test of goodness of fit, Test of Independence of attributes, Degrees of freedom for Chisquare test, Coefficient of contingency, Yates' correction for continuity.

Analysis of Variance: One way and Two way

Introduction to Model Building: Basics of Model building, Definition of a Model, Point estimation, Confidence intervals, Testing

Text & References:

- A Brief Course in Mathematical Statistics by Hogg, R.V. and Tanis, E.A
- An Outline of Statistical Theory by Goon, A.M., Gupta, M.K. and Dasgupta, B
- Continuous Univariate Distributions by Johnson, N.L., Kotz, S. and Balakrishnan, N
- Discrete Univariate Distributions by Johnson, N.L., Kotz, S. and Balakrishnan
- Fundamentals of Mathematical Statistics by Gupta, S.C. and Kapoor, V.K
- Introduction to Mathematical Statisstics by Hogg, R.V., Craig, A.T. and Mckean, J.W
- Introduction to Probability Models by Ross, S. M
- Introduction to the Theory of Statistics by Mood, A.M., Graybill, F.A. and Boes, D.C
- A first course in Probability, Sheldon Ross
- An introduction to Probability and Statistics, Vijay K. Rohatgi and A. K. Md. Ehsanes Saleh
- Biostatistics: A foundation for analysis in the Health Sciences, W.W Daniel. Publisher: John Wiley and Sons.
- Biostatistics, P.N Arora and P.K Malhan. Publisher: Himalaya Publishing House.

MIS103 Programming Fundamentals and Data Structure

Data structures and Algorithms: an overview: concept of data structure, choice of right data structures, types of data structures, basic terminology Algorithms, how to design and develop an algorithm: stepwise refinement, use of accumulators and counters; algorithm analysis, complexity of algorithms Big-oh notation. Arrays, Stack, Queue, Pointers, and Linked Lists, Arrays: Searching Sorting: Introduction, One Dimensional Arrays, Operations Defined: traversal, selection, searching, insertion, deletion, and sorting. Multidimensional arrays, address calculation of a location in arrays, sparse matrix, sparse matrix representation. Pointers: Pointer variables, Pointer and arrays, array of pointers, pointers and structures, Dynamic allocation. Linked Lists: Concept of a linked list. Circular linked list, doubly linked list, operations on linked lists. Concepts of header linked lists. Applications of linked lists, linked stacks, linked Queues.

Searching and Sorting Searching: Linear search, Recursive and Non recursive binary Search., Sorting: Selection sort, Bubble sort, Insertion sort, Merge sort, Quick sort, Shell sort, Heap sort Stacks and queues: Stacks, array representation of stack, Applications of stacks. Queues, Circular queues, array representation of Queues, Deque, priority queues, Applications of Queues.

Trees and Graphs: Introduction to trees, binary trees, representation and traversal of trees, operations on binary trees, types of binary trees, threaded binary trees, B Trees, Application of trees. Introduction to graphs, terminology, 'set, linked and matrix' representation, Graph traversal techniques: BFS, DFS, operations on graphs, Minimum spanning trees, Applications of graphs.

File Handling and advanced data Structure:

Introduction to file handling, Data and Information, File concepts, File organization, files and streams, working with files. AVL trees, Sets, list representation of sets, applications of sets, skip lists

Text & References:

- Data Structure using C and C++ - 2nd edition by Tanenbaum
- Fundamentals Of Data Structures In C++ by Ellis Horowitz, Sahni, Dinesh Mehta
- Introduction to Algorithm by Thomas H. Cormen, Charies E. Leiserson and Ronald. L. Riveit,
- The Design and Analysis of Computer Algorithms by Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman.
- Data Structures using C by A. M. Tenenbaum, Langsam, Moshe J. Augentem, PHI Pub.
- Data Structures using C by A. K. Sharma, Pearson
- Data Structures and Algorithms by A.V. Aho, J.E. Hopcroft and T.D. Ullman, Original edition, Addison-Wesley, 1999, Low Priced Edition.
- Fundamentals of Data structures by Ellis Horowitz &SartajSahni, Pub, 1983,AW
- Fundamentals of computer algorithms by HorowitzSahni and Rajasekaran.
- Data Structures and Program Design in C By Robert Kruse, PHI,
- Theory & Problems of Data Structures by Jr. SymourLipschetz, Schaum's outline by TMH
- Introduction to Computers Science -An algorithms approach , Jean Paul Tremblay, Richard B. Bunt, 2002, T.M.H.
- Data Structure and the Standard Template library – Willam J. Collins, 20

MIS104 Fundamentals of Bioinformatics

Bioinformatics and Biological Sequence Databases Overview of Bioinformatics, computational biology, History, Human Genome Project, Biological Sequence Databases (Primary, Secondary, composite), NCBI, PDB, bibliographic databases

Sequence Alignment Sequence analysis of biological data, methods of alignment and methods for optimal alignments, dynamic programming, using gap penalties and scoring matrices, multiple sequence alignment tools for MSA (MUSCLE, T-coffee), Similarity Searching Tools: BLAST and FASTA,

Molecular Phylogeny The concept of evolutionary tree terminology of phylogenetics, introduction to evolutionary models, Types of phylogenetic trees (rooted vs. unrooted trees). Phylogenetic analysis algorithms: UPGM, Fitch Morgalish, Neighbors-Relation, Neighbor-Joining, maximum Parsimony, maximum likelihood, Tree evaluation methods: Bootstrapping, Randomized and jack-knif methods

Predictive Methods Gene Identification methods, Protein structure prediction methods: Secondary and tertiary approaches

Molecular modelling & Drug designing: Overview of Molecular docking and virtual high-throughput screening,

Systems Biology: The process of system biology research, Interlinkage of Genomic, Transcriptomics, Proteomics, Lipidomic, Interactome and metabolomics

Text & References:

- Bioinformatics: Sequence and Genome Analysis, D.W. Mount, Cold Spring Harbor Laboratory Press.
- Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology, D. Gusfield, Cambridge University Press.
- Biocomputing hypertext coursebook at http://www.techfak.unibielefeld.de/bcd/Curric/welcome.html/
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, A.D. Baxevanis and B.F.F. Ouellette, Wiley-interscience.
- Computational Modeling of Genetic and Biochemical Networks, J.M. Bower and H. Bolouri, MIT Press
- Computational Molecular Biology: An Algorithmic Approach, P.A. Pevzner, MIT Press
- Computer Methods for Macromolecular Sequence Analysis, R.F. Doolittle, J.N, Abelson, M.I. Simon, Academic press
- Essentials of Genomics and Bioinformatics, C.W. Sensen, John Wiley and Sons Inc.
- Introduction to Bioinformatics, T. Attwood and D. Parry-Smith, Prentice Hall

- Introduction to Computational Biology: Maps, Sequences and Genomes, M. Waterman, Chapman and Hall
- Sequence Analysis in Molecular Biology: Treasure Trove or Trivial Pursuit, G. V. Heijne and G.V. Heijne, Academic Press

MIS105 Advances in Operating system with Unix

OS services and components, Linux File system. I/O Systems: Application I/O Interface, Kernel I/O Subsystem, multitasking, multiprogramming, time sharing, buffering, spooling

Process & thread management, context switching, multithreading

Concurrency control, mutual exclusion requirements, semaphores, monitors, Dead locks - detection, recovery, avoidance and prevention

Memory management, partitioning, swapping, paging, segmentation, virtual memory, Demand paging, page replacement and allocation algorithm

I/O Systems, interrupt handlers, device drivers, and device independent I/O software Secondary-storage structure, file system management

Protection & security, Implementation of access matrix, Encryption Case studies on Linux & Windows 2000

Introduction to Distributed Systems, Architectures of Distributed Systems, communication networks, Mutual Exclusion in Distributed Systems, RMI, concept of Replication, Distributed File Systems (NFS, AFS, coda) overview, security in Distributed Systems

Multiprocessor operating systems, basic multiprocessor system architectures, overview on Database Operating systems

Real Time Operating System and Overview on Embedded System

Text & References:

- Advanced Concepts In Operating Systems by Mukesh Singhal and Niranjan Shivaratri
- Distributed Operating systems by Andrew s.Tanenbanm
- Operating System Concepts, 5th ed. by Silberschatz and Galvin

(Practical Lab-1)

MIS191 Programming in Python

Introduction to Python: Overview of Python, applications, usage, and comparative study with other software. Basics of Python: Syntax, Data Types, Variables, Operators, Input/output, Flow of Control (Modules, Branching), Basic Programming with Python: If, If- else, Nested if-else, Looping, For, While, Nested loops, Control Structure, Break, Continue, Pass,

Data Structures of Python: Strings and Tuples, Accessing Strings, Basic Operations, String slices, Working with Lists, Introduction, accessing list, Operations, Function and Methods, Files, Modules, Dictionaries, Functions and Functional Programming, Declaring and calling Functions, Declare, assign and retrieve values from Lists, Introducing Tuples, Accessing tuples

Advanced Python: Object Oriented, OOPs concept, Class and object, Attributes, Inheritance, Overloading, Overriding, Data hiding, Operations Exception, Exception Handling, Except clause, Try finally clause, User Defined Exceptions, Python Libraries: Introduction to Machine learning packages like NUMPY, SCIPY, PANDAS etc.

Text & References:

- Think Python by Allen B. Downey
- Introducing Python by Bill Lubanovic
- Hello World by Warner Sande and Carter Sande
- Learning Python , 5th Edition , Mark Lutz
- Python For Data Analysis by W Mckinney

MIS192 Programming in R

An Introduction to R : Overview of R programming, applications, usage and comparative study with other softwares and introduction to R for Data Science

Setting up R environment and packages. : Setting up R environment and install packages and supporting libraries in R, Manage your data and workspace, Save your work, How to use R, Data structure in R, Data creation and curation and special function using R, Matrices and Lists

File Handling : Reading different file format using R, file handling and processing, writing output file.

Graphics using R: Graphics device, Basic plot function, scatter plot, 3-D scatter plot, pair plots, Lineplot, Matplot, Matpoints, Bar plot, Histogram plot, Density plot, Dot plot, Pie chart, Venn diagram, Grid graphics, Lattice, ggplot2, Interactive plotting, combine multiple plots in same graphics screen, save graphics to a file.

Programming using R: Conditional Executions, Comparison Operators, Logical Operators, Control Structures, If statements, Ifelse statements, Loops, For loop, While loop, Apply loop family, Other loops,

Functions: Define and Call functions, Syntax Rules for functions, Control utilities for functions, Writing own function

Advance R; Advance R functions and Regular expressions, Object oriented programming, Building R package

Text & References:

- A Handbook of Statistical analysis using R, Brain Everitt and Torsten Hothorn
- The art of R programming, Norman Matloff
- Data Analysis and Graphics using R, W. John Braun
- R Graphics, Paul murrell
- R for Data Science, Garrett Grolemund and Hadley Wickham
- Linear Models with R, Julian J. Faraway

(Elective papers-1)

MIS E101 Fundamentals of Physical Sciences

Mathematical Methods of Physics: Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions). Elements of computational techniques: root of functions, interpolation,

extrapolation, integration by trapezoid and Simpson's rule, Solution of first order differential equation using Runge- Kutta method. Finite difference methods. Tensors. Introductory group theory: SU(2), O(3).

Classical Mechanics :Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory. III. Electromagnetic Theory Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials.

Quantum Mechanics: Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

Thermodynamic and Statistical Physics :First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to nonequilibrium processes.

Text & References:

- Encyclopedia of Applied Physics by George L. Trigg; Eduardo S. Vera; Walter Greulich, Call Number: Ref Stacks QC5 E543 1991, ISBN: 1560810580
- Measurement Instrumentation and Sensors Handbook by Editor in Chief, John G. Webster, Call Number: Reference QC39 .M393 1999, ISBN: 0849383471
- Recent Developments in Superconductivity Research by Edited by Barry P. Martins Call Number: QC611.96 .R43 2007, ISBN: 1600214622
- Heliophysics : evolving solar activity and the climates of space and earth by edited by Carolus J. Schrijver, George L. Siscoe, Call Number: QB524 .H456 2010, ISBN: 052111294X

MIS E102 Fundamentals of Biological Sciences

Introduction: Discovery of cell, cell theory, prokaryotes and eukaryotes, evolution of eukaryotic cell. Structural organization of virus, bacteria and eukaryotic cell- ultra structure of animal cell.

Basics of molecular biology: Central dogma, structure of DNA and RNA –physical and chemical properties, re-association kinetics, Genes and chromosomes, genome organization in prokaryotes and eukaryotes. Replication and recombination, Transcription and Transalation: Gene and its control regions, structure of protein coding genes; promoter and enhancers. Coding sequences, split genes, introns, exons. Transcription in prokaryotes and eukaryotes – RNA Polymerases, structure and function, transcription factors and their functions, mechanism of transcription, spliceosomes

Regulation of gene expression Prokaryotes : concept of operon, lac operon, repressors, negative and positive control, c AMP, trp operon, attenuation, transcriptional activators, transcriptional regulatory proteins, repressors. Regulatory mechanisms in protein coding eukaryotic genes. Epigenetic Changes

Construction of genomic and cDNA library.Genomic DNA, mRNA isolation, cDNA synthesis. Methods for identification of recombinant clones. Analysis of gene expression: Northern blotting, RT – PCR, Real time (Q) PCR. Isolation of recombinant DNA clones, gene transfection / transformation in cells and tissues, knock out / in mice, animal cloning and their applications. Genome – wide high through – put analysis and its application.

Principles and Applications of Gene Transfer Technology Methods of Gene Transfer, Vectors: SV-40, Retroviral Vector, Adenoviral Vector, Adeno-associated viral vector, Vaccinia Virus vector, Methods for Gene Delivery: Chemical Method, Physical Method. Screening and selection of Transfected cells.

Cancer biology: Types of cancer; development of cancer, cells; Oncogenes, protooncogenes , function of oncogene products , tumor suppressor genes , function of tumor suppression gene products, role of oncogene and tumor suppressor gene in development, molecular diagnosis of cancer.

Text & References:

- Lehninger Biochemistry, Nelson & Cox 6th edition, W.H. Freeman & Company
- Harper's Illustrated Biochemistry by Robert K. Murray, Lange
- Biochemistry C.K. Mathews, K. E. Van Holde, K. G. Ahern Pearson Education, N Delhi 2003
- Biochemistry J. M. Berg, J. L. Tymoczko & L. Stryer W.H.Freewan & Co., NY , 2004 Biochemistry and Mol. Biology W.H. Elliott & D.C. Elliott Oxford Press, Oxford 2005
- Chemistry for Life Sciences Sutto R., Rockett B. & Swindells P Taylor & Francis, London 2000
- Cell and Molecular Biology De Robertis, E.D.P. and De Robertis E M F
- Cell and Molecular Biology Garald Karp J. Wiley & Sons, NY
- Jocelyn E.K, Elliott S.G and Stephen T.K. 2011. Lewins Genes X. Jones and Barlett Pub., USA
- Watson J.D, Tania A.B, Stephen P.B, Alexander G, Michael L and Richard L. 2007. Molecular Biology of the Gene. Benjamin Cummings.

MIS E103 Fundamentals of database management system

Overview of Database Management, Conceptual Database Design, Logical Database Design,Physical Database Design

Introduction to Relational Database : Relation, Optimization, The Catalog, Base Relvars and Views, Transactions, The Suppliers and Parts Database. Relational Model Concepts, Relational Model, Constraining, Referential Integrity Constraints, Defining Referential Integrity Constraints, Update Operations on Relations, Structured Query Language (SQL), Data Definition Language Commands, Data Manipulation Language Commands, Transaction Control Commands, SQL Command Syntax and Usage, The Basic Query Block, Querying Data with Multiple Conditions, Basic Relational Algebra Operations, The Select Operation, Additional Relational Operations.

ER- and EER-to-Relational Mapping: ER- to Relational Mapping Algorithm, Summary of Mapping for Model Constructs and Constraints Mapping EER Model Concepts to Relations, Query, Processing and Optimization: Query Processing, Query Optimization, Database Tuning.

Object Oriented Database Systems: Characteristics of an Object-relation Database Management System (ORDBMS), Complex Objects, Inheritance, Function Overloading, Rules.

Distributed Database : Distributed Database System, Distributed Database Design, Data Fragmentation, Data Replication, Data Allocation, Query Processing in Distributed Databases.

Recovery : Transactions, Transaction Recovery, System Recovery, Media Recovery, Two-phase Commit.

Database Security : Security and Integrity Threats Intentional or Malicious Threats Defense Mechanisms, Security Policies, Authorization, Objects, View as objects, Granularity, Subject, Access Types.

Database Operating Systems : Features of a Database as Concurrency Control, A Concurrency Control Model Theory of Serializability Concurrency Control Algorithms, Concurrency Control Based on Timestamp Ordering Multiversion Concurrency Control Techniques, Optimistic Algorithm.

Multimedia Databases : Multimedia Data Formats, Continuous - Media Data, Similarity - Based Retrieval, Mobility and Personal Database, Database Technologies, Serving Database on the Web, Applying Databases to the Internet.

Text & References:

- Database System Concepts – 6th Edition by Silberschatz, Korth and Sudarshan
- Fundamentals of Database Systems – 5th Edition by R.Elmasri, S. Navathe
- Database Design and Relational Theory: Normal Forms and All That Jazz by C.J. Date

Second Semester

MIS201 Mathematical modelling in biology

- Linear difference equations (Breathing model) and Nonlinear difference equations for Apoptosis and tumorigenesis model
- Systems of nonlinear difference equations; host-parasitoid system models (The Nicholson-Bailey Model), Steady States, Stability, Bifurcations
- Systems of differential equations; Chemostat model; phase plane analysis
- Enzyme Kinetics and chemical reactions: Michaelis-Menten theory, Hormone cycles, neuron-firing.
- The Spruce Budworm Outbreak Model
- Infectious disease models (SIR and SIRS models,
- Pharmacokinetic models; Cancer models
- Example of Cell cycle model; Neuroscience modeling
- Continuous Models
- Complex Disease Association Studies

Text & References:

- "Modeling and Simulation in Python" by Allen B. Downey
- "Introduction to Mathematical Modeling" by Edward A. Bender and S. Gill Williamson. T
- "Modeling and Analysis of Dynamic Systems" by Charles S. Peskin.
- "A Course in Mathematical Modeling" by David A. Kendrick.
- "Modeling and Simulation of Complex Systems: A Framework for Textbook and Research" by Peter G. Harrison.
- Modeling Life, The Mathematics of Biological Systems, Alan Garfinkel , Jane Shevtsov , Yina Guo
- Mathematics Applied to Deterministic Problems in the Natural Sciences, C. C. Lin and L. A. Segel

MIS202 Advances statistics and Linear Algebra

Linear algebra, Solving systems of equations with matrices, Singular value decomposition, Linear dependence and independence., Stocahstic process theory and applications

Simple linear regression: Estimation of the Parameters, Hypothesis Testing on the Slope and Intercept, Interval Estimation in Simple Linear Regression, Prediction of New Observations, Coefficient of Determination

Multiple regression: Estimation of Parameters, Hypothesis Testing, Confidence Intervals, Prediction

Model Adequacy testing: Residual Analysis, PRESS statistic, Lack of Fit **Transformations:** Variance stabilising transformations, Transformations to linearise the model, Methods to select a transformation, Weighted least squares, Regression and random effect

Multicollinearity: Sources, Effects, Diagnostics, Methods of dealing with Multicollinearity

Validation of regression models: Techniques for validation

Introduction to non linear regression and GLM: Non linear least squares, Transformations, Parameter estimation, Logistic and poisson regression

Text & References:

- Functions of one complex variable by John Conway
- Complex Analysis by L V Ahlfors
- Complex Analysis by J Bak and D J Newman http://entrance-exam.net/reference-books-for-delhi-university-msc-in-mathematics-entrance-exam/
- Abstract Algebra by David S. Dummit and Richard M. Foote
- Algebra by M. Artin
- Basic Algebra by Jacobson
- Complex numbers from A to --- Z by T.Andreescu, D.Andrica
- Contemporary Abstract Algebra (4th Edition), by Joseph A. Gallian
- Linear Algebra and its Applications by David C. Lay
- Introduction to Linear Regression Analysis, by Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining
- Introduction to Regression Analysis, M. Golberg and H.A Cho
- Applied Regression Analysis, Norman R. Draper and Harry Smith

MIS203 Graphs and Networks for complex system

Fundamental concepts of graphs Basic definitions of graphs and multigraphs; adjacency matrices, isomorphism, girth, decompositions, independent, sets and cliques, graph complements, vertex coloring, chromatic number, important graph like cubes and the Petersen graph, Paths, cycles, and trails; Eulerian circuits. Vertex degrees and counting; large bipartite subgraphs, the handshake lemma, Havel-Hakimi Theorem, Directed graphs: weak connectivity, connectivity, strong, components, Induction and other fundamental proof techniques

Trees Basics: equivalent characterizations of trees, forests, Spanning trees and 2-switches, Distance and center, Optimization: Kruskal's Theorem and Dijkstra's Theorem

Matching and covering Bipartite matching, vertex cover, edge cover, independent set, M-alternating path, Hall's Theorem, König-Egeváry Theorem, Gallai's Theorem

Connectivity and Network flow Vertex cuts, separating sets, bonds; vertex and edge connectivity, block-cutpoint tree, Menger's Theorem: undirected vertex and edge versions, Ford-Fulkerson Labeling algorithm, flow integrality, Max-flow/Min-cut Theorem, proof of Menger's Theorem

Random Networks: Erdos-Renyi model, Small-world effect, clustering coefficient. Scale-free networks: Power laws, Hubs, ultra-small property, degree exponent, The Barabasi-Albert Model. Degree correlations: assortativity and disassortativity.

Coloring and Planarity Chromatic number: lower bounds from clique number and maximum independent set, upper bounds from greedy coloring (& Welsh-Powell), Szekeres-Wilf, and Brooks' Theorem. Also k-critical graphs, cartesian product of graphs, and interval graphs, k-Chromatic graphs: Mycielski's construction, Turán's Theorem, Edge coloring, line graphs, Vizing's Theorem Embeddings, dual graphs, Euler's formula Kuratowski's Theorem, Coloring, including the 5-color theorem

Text & References:

- A Walk Through Combinatorics, Miklos Bona
- Doug West, Introduction to Graph Theory
- Alan Tucker's Applied Combinatorics
- Pearls in Graph Theory: A Comprehensive Introduction by Nora Hartsfield
- Introduction to Graph Theory by Richard J. Trudeau
- Graph and Digraphs, by Chartrand, Lesniak, and Zhang
- Bollobás's Modern Graph Theory

- Introduction to Graph Theory by Wilson.
- Graph Theory: Modeling, Applications, and Algorithms by Geir Agnarsson
- Networks: An Introduction by M.E.J. Newman, Oxford University Press, 2010.
- Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall/CRC, 2007.
- Introduction to Systems Biology, S. Choi, Humana Press, 2007.
- Linked – The New Science of Networks, Albert-László Barabási, Perseus Publishing, 2002.

MIS204 Numerical Techniques and Programming

Preliminaries of Computing, a) Basic concepts: round-off errors, floating point arithmetic, Convergence.
Numerical solution of Nonlinear Equations, a) Bisection method, fixed-point iteration, Newton's method, b) Error analysis for Iterative Methods, c) Computing roots of polynomials.
Interpolation and Polynomial Approximation, a) Lagrange Polynomial, b) Divided Differences, c) Hermite Interpolation
Numerical integration and differentiation, a) Trapezoidal rule, etc., Gaussian quadrature and Euler-Maclaurin formula.
Applied Linear Algebra, a) Direct methods for solving linear systems, numerical factorizations, b) Eigenvalue problems.
IVP problems for ODE, a) Euler's, Taylor, Runge-Kutta, and multistep methods, Stability.
Numerical linear algebra, a) Direct methods, b) Iterative methods
Approximation theory, Least square approximation
Approximating Eigenvalues, Power method, Householder's method
BVP for ODE, Shooting methods

Text & References:

- Theory of Computer Science, Mishra & Chandrasekharan, PHI
- Discrete Mathematics for Comp. Scientists & Mathematicians, Mott, Kandel & Baker, PHI
- Discrete Mathematical Structure, C.L.Liu,TMH
- Discrete Mathematical Structure, G.S.RAO
- Numerical Analysis, Shastri, PHI
- Numerical Methods for Mathematics ,Science & Engg., Mathews, PHI
- Numerical Analysis & Algorithms, Pradeep Niyogi, TMH
- J. Stoer and R. Bulirsch, Introduction to Numerical Analysis, Springer-Verlag, ISBN 0-387- 90420-4
  L.N. Trefethen and D. Bau, Numerical Linear Algebra, Society of Industrial and Applied Mathematics
- C.T. Kelley, Iterative methods for linear and nonlinear equations, Society of Industrial and Applied Mathematics

MIS205 Omics Sciences

Genomics: Major genome sequencing projects, Next Generation Sequencing technologies, File formats, Basic pipeline for data analysis – quality check, adaptor trimming, Genome assembly, Genome annotation, Concepts of sequencing coverage and sequencing depth, phred score, N50, Introduction to different tools and algorithms, Data repositories and databases, Choice of sequencing platforms, Applications of genomics using case studies

Transcriptomics: Introduction to typical wet lab workflow, library preparation, and analysis pipeline, Choice of sequencing methods and tools for read mapping, assembly, identification of splicing variants and differential expression analysis, Tools available for pathways analysis, Gene Ontology, Hypergeometric enrichment analysis, Biogenesis, characteristics and analysis of small RNA like microRNAs and phasiRNAs, Analysis of long non-

coding RNAs, Target prediction and functional prediction for small RNAs and lncRNAs, Applications of transcriptomics using case studies

Proteomics and Lipidomics: Basic tools and techniques for protein separation and analysis, Mass spectrometry based proteomics: basic workflow and analysis pipeline, Quantitative proteomics and multiplexing, large scale analysis of protein modifications. Software packages and available tools for proteomics data analysis. Applications of mass spectrometry and proteomics using case studies.

Epigenomics: Epigenetic mechanisms of gene regulation, DNA methylation, Histone modifications, Epigenetics databases, Analysis of epigenetic profiles,NGS epigenetic data analysis

Metabolomics and Fuxomics: Tools and techniques available for metabolomics analysis, targeted vs non-targeted metabolomics, experimental design and sample preparation, workflow, data analysis tools and repositories, data formats and key challenges, metabolite identification, metabolic fingerprinting, applications of metabolomics.

Text & References:

- Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press.
- Mass Spectrometry for Biotechnology by Gary Siuzdak, Academic Press.
- Proteomics for Biological Discovery by Timothy Veenstra and John Yates, Wiley.
- Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
- Lipidomics- Technologies and Applications by Kim Ekroos, Wiley-VCH.
- Web/Journal Resources.
- Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing, 2009 – Science

MIS206 Computational Structural Biology

Fundamentals of biomolecular structure: Key concepts for the protein, DNA and RNA structures. Molecular interactions in tertiary structure, Fold space and evolution of the proteins. The quaternary structure of proteins and their association. Base-pair geometry in nucleic acids, conformation of the sugar phosphate backbone. DNA quadruplexes, RNA duplexes. Mismatched in bulged RNA. Structure and function of Ribosome.

Computational aspects of macromolecular structure and assemblies: The structure of macromolecules and their file format. Introduction to computer programs to handle these files. Methodology for all atom contact analysis. Methods for structural comparison. Mapping protein fold space. The impact of structural genomics.

Structure and function assignment of macromolecules: Computational methods for structural assignment of proteins and nucleic acids. Identification of structural domains. Folding of protein and nucleic acids. Flexibility in macromolecules. Surface cleft and binding pockets. High throughput function prediction. Structure prediction and overview on CASP.

Structural annotation of Genomes: Availability of completed genomes. Methodologies available for identifying structural protein domains in genomes. Structural genome annotation resources. Structure based alignment and structural Blast – VAST, DALI

Macromolecular interactions: Bonded and non-bonded interactions involved in folding and assembly of macromolecules. Analysis of intra and intermolecular interactions in the stability of macromolecules and their assembly. Prediction of protein-protein and protein-nucleic acids interactions.

Molecular modelling Protein structure prediction methods: Secondary and tertiary approaches, Computational methods for the identification of membrane proteins and the prediction of their structures. The significance and impacts of protein disordered and conformational variants. Ramachandran Plot. Future challenges: Folding process for proteins and membrane proteins.

Text & References:

- Proteins structures and molecular properties by T. E. Creighton.
- Structural Bioinformatics by Jenny Gu and Philip E. Bourne
- Bioinformatics and Functional Genomics by J. Pevsner
- Protein-protein complexes; analysis, modeling and drug design. Edited by Martin Zacharias.
- Computational Structural Biology: Methods and Applications by Torsten Schwede and Manuel C. Peitsch.
- Molecular conformation and Biological interactions by P. Balaram and S. Ramaseshan.

(Practical Lab-2)

MIS291 Laboratory-II (Mathematical Modelling, Computational Structural Biology)

- Infectious disease models (SIR and SIRS models)
- Pharmacokinetic models; Cancer models
- Complex Disease Association Studies
- Protein structure prediction methods: Secondary and tertiary approaches,
- Assessment of predictive 3d protein structure using Ramachandran Plot.

(Elective papers-2)

MIS E201 Biological Sequence Analysis

Bioinformatics and Biological Sequence Databases: Overview of Bioinformatics, computational biology, History, Human Genome Project, Biological Sequence Databases (Primary, Secondary, composite), NCBI, PDB, bibliographic databases, Ensembl database

Sequence Alignment: Sequence analysis of biological data, methods of alignment and methods for optimal alignments, dynamic programming, using gap penalties and scoring matrices, multiple sequence alignment tools for MSA (Clustalx, MUSCLE, T-coffee), Similarity Searching Tools: BLAST and FASTA,

Molecular Phylogeny: The concept of evolutionary tree terminology of phylogenetics, introduction to evolutionary models, Types of phylogenetic trees (rooted vs. unrooted trees).Phylogenetic analysis algorithms: UPGMA, Fitch Morgalish, Neighbors-Relation, Neighbor-Joining, maximum Parsimony, maximum likelihood, Tree evaluation methods: Bootstrapping, Randomized and jack-knifing methods

Predictive Methods Gene Identification methods, Finding Open Reading Frames (ORFs)

Comparative genomics: Phylogenetic analyses to determine relationships and interpret character evolution

Functional analysis; Gene set enrichment analysis, Gene Ontology enrichment analysis, functional pathway analysis

Text & References:

- Bioinformatics: Sequence and Genome Analysis, D.W. Mount, Cold Spring Harbor Laboratory Press.
- Algorithms on Strings, Trees, and Sequences: Computer Science and Computational Biology, D. Gusfield, Cambridge University Press.
- Biocomputing hypertext coursebook at http://www.techfak.unibielefeld.de/bcd/Curric/welcome.html/
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, A.D. Baxevanis and B.F.F. Ouellette, Wiley-interscience.

- Computational Modeling of Genetic and Biochemical Networks, J.M. Bower and H. Bolouri, MIT Press
- Computational Molecular Biology: An Algorithmic Approach, P.A. Pevzner, MIT Press
- Computer Methods for Macromolecular Sequence Analysis, R.F. Doolittle, J.N, Abelson, M.I. Simon, Academic press
- Essentials of Genomics and Bioinformatics, C.W. Sensen, John Wiley and Sons Inc.
- Introduction to Bioinformatics, T. Attwood and D. Parry-Smith, Prentice Hall
- Introduction to Computational Biology: Maps, Sequences and Genomes, M. Waterman, Chapman and Hall
- Sequence Analysis in Molecular Biology: Treasure Trove or Trivial Pursuit, G. V. Heijne and G.V. Heijne, Academic Press

MIS E202 Working with MySQL

SQL (Structured Query Language), Data Definition Language (DDL): Create, Alter, and Drop commands

Data Manipulation Language (DML): Select, Insert, Update, and Delete commands, Basic SQL queries, Integrity constraints on tables,

Data Control Language Commands (DCL): Grant and Revoke, Transaction Control Language Commands (TCL): Commit, Rollback, Savepoint, Autocommit,

SQL Functions, SQL querying to do operations such as identifying nulls, special characters, blank rows/columns, and run distributions, run data summaries, merge tables, get unique counts

SQL Joins, Aggregate functions, and GROUP BY, Nested queries and sub queries. GROUP BY CLAUSE along basic aggregations such as SUM, COUNT, AVG RANK (), ROWNUM () & DENSE_RANK. UNION and UNION ALL CASE statement

Introduction to Advanced SQL concepts: Indexes, Sequence, Clusters, Views, Cursors and Triggers, Embedded SQL

Text & References:

- Database System Concepts, Abraham Silberschatz, Henry F. Korth, and S. Sudarshan
- An Introduction to Database Systems, C J Date Fundamentals of Databases – Elmasri and Navathe.
- Database Management Systems – Raghu Ramakrishna, Johannes Gehrke

MIS E203 Chemoinformatic in drug designing

Drug designing and Discovery Overview of new drug discovery, development, cost and time lines. Target Identification & Validation. Lead Discovery: Rational and irrational approaches - Drug repurposing, Natural products, Molecular docking and High-throughput screening (HTS), Combinatorial chemistry and computer aided drug design (CADD).

ADMET and PK/PD: Hit to Lead to Drug, Prediction of Absorption and Molecular Physical Properties, Permeability/Solubility/Stability(LogP/LogD/pKa),

Overview on docking methods HADDOCK, ATTRACT, HEX, ligand design, and validating data sets. Search algorithms in docking and scoring function. Binding site prediction and annotation. Overview on CAPRI.

Methods in Drug design; Chemical databases, 2D and 3D database search, Similarity Search, Scaffold hoping, Lead identification, Pharmacophore modeling and lead identification, Lead Optimization and Library Design,

optimization and validation, Docking, De Novo Drug Design, Virtual screening. Quantitative structure activity relationship; Introduction to QSAR, descriptors QSARs, combinatorial libraries.

Molecular modelling in Drug design:- Conformational analysis, lead identification, optimization and validation. Methods and Tools in Computer-aided molecular Design, Analog Based drug design:-Pharmacophores and QSAR. Structure based drug design:- Docking, De Novo Drug Design, Virtual screening

Structure Activity Relationship: Introduction to QSAR, QSPR, Various Descriptors used in QSARs

Text & References:

- Burger's Medicinal Chemistry and Drug discovery. Volume 2, Drug Discovery and
- development.6th Edition. Ed Donald J Abraham Wiley- Interscience.
- Essentials of Medical Pharmacology, 6the Edition (Hardcover) by Tripathi Kd. Publisher:
- Jaypee Brothers (2008)
- Laws of Patents: Concepts and Cases Edited by A. V. Narasimha Rao © 2005 The ICFAI
- University Press
- Intellectual Property Rights In India: General Issues And Implications by Prankrishna
- Pal. Publisher: Deep & Deep Publications Pvt.Ltd (2008)
- Drugs: From discovery to approval 2nd Ed by Rick NG. Wiley Blackwell (2009)
- Intellectual Property Rights by Deborah E. Bouchoux,. Delmar Cenage Learning. 2005

MIS301 Research Methodology

Introduction to Research Methodology: meaning, objective and motivation in interdisciplinary research area, research formulation, Importance of literature review, Different types of research methodology, descriptive vs analytical, Applied vs fundamental, Quantitative vs Qualitative, Conceptual vs empirical

Research Methods and Design: problem identification and hypothesis testing, experimental design, sampling and variables

Data Analysis and Interpretation: Univariate and bivariate analysis, Data normalization and scaling, application of basic statistical tools to association and prioritization of research topics

Research ethics and data protection, ethical issue related to research, sample collection and collection of data. Ethical issues in using artificial intelligence, Government guidelines such as ICMR for data use of AI, data and data collection.

Report/Manuscript writing and presentation: format for research articles and reviews, language editing, , plagiarism, scientific presentation tips and citing relevant scientific literature. Writing thesis in Latex, Working with thesis, Literature and reference management, Citation style management, Mendeley and EndNote etc.

Intellectual property rights: The Patent's act, Protectable Subject Matter- patentable invention, Procedure for Obtaining patent, Provisional And Complete Specifications, Rights conferred on a Patentee, Transfer of Patent, Revocation and surrender of Patents. Infringement of patents, Action for Infringement, Patent Agents, Patent in Computer Programs, Patent Protection for Microorganisms. Brief Discussion on Case Law on Patents.

Text & References:

- ROIG (M). Avoiding plagiarism, self-plagiarism, and other questionable writing practices: A guide to ethical writing (2006)
- VAUGHAN (L). Statistical methods for the information professional: A practical, painless approach to understanding, using and interpreting statistics (Ed. 2), (2004) Information Today, Medord.
- Kothari C.K. (2004) 2/e, Research Methodology – Methods and Techniques (New Age International, New Delhi)
- Mathews. "Successful scientific writing: A step-by-step guide for Biomedical Scientists", Second edition, Cambridge University Press, 2001.
- https://main.icmr.nic.in/sites/default/files/upload_documents/Ethical_Guidelines_AI_Healthcare_2023.pdf
- Research Methodology and Scientific Writing by C. George Thomas (2016) Ane Books Publisher

MIS302 Data Mining and Modeling

Introduction to Data Mining. Different kinds of data and patterns that are mined. Technologies used. Applications, Major Issues. Data Objects and Attribute Types, Basic tatistical Description of Data, Data visualisation, Measuring Data Similarity and dissimilarity. Data Pre-processing, Data cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization.

Data mining algorithms: Association Rule Mining, Classification and Prediction: -Issues Regarding Classification and Prediction, Classification by Decision Tree. Introduction, Bayesian Classification, Rule Based Classification, Classification by Back propagation, Support Vector Machine , Associative Classification , Lazy Learners , Other Classification Methods

Types of Data in Cluster Analysis, Model-Based Clustering Methods, Hierarchical and Partitioning methods. Outlier–Outlier detection techniques. Data mining Applications, Data mining and society. Data mining Trends, Data mining software.

Advanced Techniques, Web Mining, Text mining, Spatial and Temporal Mining. Sequential Pattern Mining Mining Spatiotemporal and Trajectory Patterns, Multivariate Time Series (MVTS) Mining, Bayesian approach to classifying text. Web mining: classifying web pages, extracting knowledge from the web

Text & References:

- J Han, M Kember, J Pei, Morgan Kaufman, "Data Mining : Concepts and Techniques" , 3rd ed.,
- Alex Berson,Stephen J. Smith, "Data Warehousing, Data Mining, & OLAP", Tata McgrawHill, 2004.
- Berry Micheal and Gordon Linoff, Mastering Data Mining. John Wiley & Sons Inc.
- Witten, E. Frank, M. Hall. "Data Mining: Practical Machine Learning Tools and Techniques", Morgan Kaufmann Publishers, 2011.

MIS303 Systems Biology

Systems Biology

The process of system biology research, Interlinkage of Genomic, Transcriptomics, Proteomics, Lipidomic, Interactome and metabolomics, Gene Ontologies.

Classification of Enzymes and Metabolic Pathways; KEGG database. Metabolic Pathways, Organism Specific Metabolic Pathways, Metabolic Control Analysis & Engineering of Metabolic Pathways.

Biological networks: Complex Biological Systems, Types of Biological networks, Intra-cellular networks: Gene-regulatory network, Protein-interaction network, Metabolic networks and Signaling network; Inter-cellular networks: Neuronal networks, Network motifs, Network medicine.

Modularity: Motifs and sub-graphs, Feed-forward loops, Single-input modules: LIFO, FIFO. Dense overlapping regulons (DORs). Optimal gene design circuits: fitness function and optimal expression of a protein in bacteria, Robustness.

Constraint-based modelling – Metabolic reconstruction, Flux Balance Analysis (FBA): Translating biochemical networks into linear algebra, Stoichiometric matrix, Elementary mode, Extreme pathways, Objective function, Optimization using linear programming. Genome-scale cellular models: Virtual Erythrocytes, Global human metabolic model (Recon 1).

Applications: Regulatory (e.g. fly), Signal transduction (e.g. MAP Kinase cascade in yeast), Neural, Mechanical, etc. Quantitative models for E Coli: lac operon and lambda switch, Dynamical systems, linear stability and bifurcation analysis. Limit cycles, attractors. SBML, and open source programs like eCell, Virtual Cell, StochSim, BioNets, etc.

Text & References:

- Hiroaki Kitano, ed, Foundations of systems biology, MIT Press 2001
- JM Bower and H Bolouri, eds, Computational modeling of genetic and biochemical networks,
- MIT Press 2001
- GB Benedek and FMH Villars, Physics with illustrative examples from medicine and biology, Vol. 1: Mechanics, 2nd ed, Springer 2000.
- Klipp E Wolfran L, System Biology: A Text Book Wiley-VH VerlagGmbh ,2009
- Choi Sangdun, Introduction to System Biology Humana Press/Trtowa/New Jersey Alon Uri, Introduction to Systems Biology: Design Principles of Biology Circuits Chapman & Hall/CRC/2007
- Alberghina L, System Biology: Definitions and Perspectives Springer- Verlag/Berlin/Heidlberg
- Lee SY, System Biology & Biotechnology of Escherichia Coli
- Najaviark, System Biology and Bioinformatics; A Computational Approach

- Lee A Segel, Biological Kinetics CUP Cambridge
- Ethel Cornish Bowden, Fundamentals of enzyme kinetics.

MIS304 Biomolecular simulation theory and application

Molecular Mechanics: Basic thermodynamics and Molecular mechanics, Analysis of protein content and organization; Analysis of protein structures, comparative modeling, structure prediction algorithms and tools, threading empirical force field models; Bond stretching, angle bending and torsional terms, the harmonic oscillator model for molecules. Morse Potential, Non-bonded interactions; Van der Waals, electrostatic and hydrogen bonding, Types of Potentials: Lennard-Jones, Truncated Lennard-jones, Exponential-6, Ionic and Polar potentials. United atom force fields and reduced representations, Force field parameterization. Types of Force Fields: AMBER, CHARMM, Merck Molecular Force Field, Consistent Force Field, MM2, MM3 and MM4 force fields.

Potential energy surface; Convergence criteria, Optimization; multivariable optimization algorithms, minimization methods, steepest descent and conjugate gradient methods.

Molecular dynamics Simulations; Newtonian dynamics; Integrators - Leapfrog and Verlet algorithms, truncated and shifted-force potentials. Implicit and explicit solvation models, periodic boundary conditions. Temperature and pressure control in molecular dynamics simulations. Conformational analysis; Evolutionary algorithms and simulated annealing, clustering and pattern recognition techniques.

Monte Carlo Simulation methods; Theoretical aspects and implementation to the Metropolis method, configurationally biased Monte Carlo simulations.

Software to implement Simulations: Protein unfolding and membrane simulations with software such as GROMACS, NAMD, AMBER

Texts and References:

- A. R. Leach, Molecular Modeling Principles and Applications, 2nd Edition, Prentice Hall USA, 2001.
- T. Schlick Molecular Modeling and Simulation - An Interdisciplinary Guide, Springer verlag, 2000.
- B. R. Donald, Algorithms in Structural Molecular Biology, Massachusetts Institute of Technology Press, 2011.
- A. Hinchliffe, Molecular Modeling for Beginners, 2nd Edition, John Wiley & Sons Ltd, 2008.
- P. E. Bourne, Structural Bioinformtics, 2nd Edition, Wiley, 2009.
- D. W. Mount, Bioinformatics: Sequence and Genome Analysis, 2nd Edition, CSH Press, 2005.
- S. G. Kochan and P. Wood, UNIX Shell Programming, 3rd Edition, SAMS, 2003.
- P. Bultinck, Computational Medicinal Chemistry for Drug Discovery, Marcel Dekker Inc., 2004.

MIS 305 Non-linear Dynamics

Introduction to Dynamical Systems: Representations of Dynamical Systems, Vector Fields of Nonlinear Systems, Limit Cycles, Nonlinear systems and their classification, Existence and uniqueness of solutions, Fixed points and Linearization, Stability of equilibria, Conservative and dissipative systems.

Tools for Detecting Chaos: Centre manifold theory and Poincare maps, Lyapunov Exponents, phase plane, Stable and Unstable Manifolds, Dynamics on a Torus, analysis of Chaotic Time Series.

Discrete Time Dynamical Systems: Poincare section, Logistics map, Henon map, strange attractors

Theory of Bifurcations: Saddle-node, transcritical, pitchfork bifurcations, Hopf bifurcation, global bifurcations, Stable and Unstable Manifolds, Center manifold theory.
Examples of chaotic systems: Lorenz Equation, Rossler Equation, Forced Pendulum and Duffing oscillator, Chua's Circuit

Analysis, Control, and Application of Chaos: Need for chaos control, the OGY method, optimal control, Adaptive control, Non-feedback control, Feedback control,

Chaos Synchronization and its Applications: Types and method of synchronization, synchronization in complex systems, synchronization technique

Text & References:

- Strogatz, S. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering. CRC Press, 2020. ISBN: 9780738204536.
- Berge, P., Y. Pomeau, and C. Vidal. *Order within Chaos: Towards a Deterministic Approach to Turbulence.* Wiley-VCH, 1987. ISBN: 9780471849674. (An undergraduate-level physical introduction to the subject.)
- Cross, M. and H. Greenside. *Pattern Formation and Dynamics in Nonequilibrium Systems*. Cambridge University Press, 2009. ISBN: 9780521770507.
- Cvitanovic, P. *Universality in Chaos.* Adam Hilger, Ltd., 1989. ISBN: 9780852747650. (Contains reprints of a number of original research papers in the field.)
- Cvitanovic, P., R. Artuso, R. Mainieri, G. Tanner, and G. Vattay. *Chaos: Classical and Quantum* (PDF - 8.4 MB)
- Gleick, J. *Chaos*. Viking Books, 1987. ISBN: 9780749386061. (An excellent popular introduction.)
- Guckenheimer, J. and P. Holmes, *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields.* Springer, 1983. ISBN: 9780387908199. (A graduate-level applied mathematics textbook.)
- Schuster, H. and W. Just. *Deterministic Chaos: An Introduction*, 4th edition. Wiley-VCH, 2005. ISBN: 9783527404155. (An advanced book of interest to physicists.)
- Turcotte, D. *Fractals and Chaos in Geology and Geophysics*, 2nd edition. Cambridge University Press, New York, 1997. ISBN: 9780521567336.

MIS 306 Data Science and Machine Learning

Introduction to Data Science: Key components in Data Science , Use cases from different application domains such as Banking, Retail, Telecom, Life Science and Healthcare, etc, Challenges involved in Data Science, Ethics in Data Science

Characteristics of Data – Big data introduction, Structured, Semi-structured and Unstructured data, data at rest, data in motion, etc, Good data versus bad data, Challenges in handling large data sets, Data Science tools and technologies

Introduction to machine learning, What is ML, Types of ML, Applications used for ML, AI vs ML, Essential for ML and AI. Introduction to Supervised, unsupervised, semi-supervised, and reinforced machine learning techniques

Data Pre-processing: Data description, Data processing, Dimension Reduction, Comprehend the meaning, process, and importance of data preparation, feature engineering and scaling of datasets, normalization of data

Resampling methods Discuss different cross validation techniques. Leave-One-Out Cross-Validation, k-Fold Cross Validation

Text & References:

- Programming Collective Intelligence by Toby Segaran
- Machine Learning for Hackers by Drew Conway and John Myles

- Machine Learning by Tom M. Mitchell
- Pattern Recognition and Machine Learning by Christopher M. Bishop (Author)
- Machine Learning Yearning by Andrew NG
- The Elements of Statistical Learning by Trevor Hastie , Robert Tibshirani , Jerome Friedman

(Practical Lab-3)

MIS391 Laboratory-III (System Biology, Data Mining, Biomolecular Simulation)

System Biology

1. Creating Gene-regulatory network,
2. Protein-interaction network,
3. Creating metabolic network (Flux)

Data Mining:

4. Pre-process a data set taken from UCI/ Kaggle in structured and unstructured formats and apply normalization techniques. Visualize data sets pre-processed in the above.
5. Carry out k-means clustering on a given multivariate data both with and without pre-processing.

Biomolecular Simulation

6. Writing a simulation code from scratch.
7. Interpreting the results from a simulation. Convergence of simulation.
8. Introduction to packages for macromolecular simulation (AMBER/GROMACS)
9. Simple examples
10. Exercise in computer simulation of proteins.

(Elective papers-3)

MIS E301A Analysis of Next generation sequencing Data

Introduction to NGS and NGS Technologies: Introduction to sequencing technologies from a data analysts view, Concept, Applications of sequencing technologies in Whole genome assembly; Gene expression analysis; Genome annotation; Gene regulation analysis; Variation studies

NGS data analysis: Preprocessing: Introduction to NGS data analysis, Raw sequence files (FASTQ format), Preprocessing of raw reads: quality control (FastQC), adapter clipping, quality trimming, Introduction to read mapping (Alignment methods, Mapping heuristics), Read alignment to a reference genome (BWA, Bowtie2, TopHat), Mapping output (SAM/BAM format), Usage of important NGS toolkits (samtools, BEDtools), Mapping statistics, Visualization of mapped reads (IGV, UCSC)

NGS data analysis: Variant calling, DNA variant calling and Filtering DNA variants using GATK pipeline, deep variant, Genomics and transcriptome assembly, Differential Expression analysis, Copy number variation

Non-coding RNAs: Small RNAs, miRNAs, long non-coding RNAs; sequencing and prediction methods; biological relevance

Text & References:

- Exploring Personal Genomics, 1st Edition, Joel T. Dudley, Konrad J. Karczewski, ISBN-13: 978-0199644490, Oxford University Press, 2013
- High-Throughput Next Generation Sequencing, Methods and Applications,Editors: Kwon, Young Min, Ricke, Steven C. (Eds.), ISBN 978-1-61779-089-8, Springer, 2011
- Next Generation Sequencing Technologies and Challenges in Sequence Assembly, El-Metwally, M.Sc, Sara, Ouda, Osama M., Helmy, Mohamed, ISBN 978-1-4939-0715-1, Springer 2014

MIS E301B Database advance (NoSQL Databases)

Introduction, Non-relational databases, Types and advantages of NoSQL Databases, Comparison with relation databases and SQL databases, example of NoSQL Databases

MongoDB: MongoDB's key features, MongoDB's core server and tools, Why MongoDB? , History of MongoDB, Diving into the MongoDB shell, Creating and Querying with indexes, Basic Administration, Writing Program using MongoDB

Apache Cassandra: Big Data and Apache Cassandra, Importance of Cassandra, Cassandra as a Distributed Database, Cassandra and High Availability, Cassandra and Replication Mechanism, Cassandra's Elastic Scalability, Tune able consistency (Strict Consistency , Casual Consistency , Weak Consistency , Brewer's CAP Theorem , Cassandra as a Schema Free Database, Where should we use Cassandra , Who and why using the CassandraBigTable

BigTable: Introduction, advantage, Architecture of BigTable, Load balancing, Security, encryption and backup, consistency model.

Text & References:

- MongoDB: The definitive guide by Kristina Chodorow, Michael Dirolf
- Cassandra: The Definitive Guide, Eben Hewitt
- MangoDB in Action, Kyle Banker, Peter Bakkum, Shaun Verch, Douglas Garrett, Tim Hawkins

MIS E301C Soft Computing and optimization technique

Introduction to Soft Computing Concept of computing systems., soft vs hard computing hard computing, Characteristics of Soft computing, Applications of Soft computing techniques

Fuzzy logic Fuzzy Set theory, Fuzzy versus Crisp set, Fuzzy Relation, Fuzzification, Minmax Composition, Defuzzification Method, Fuzzy Logic, Fuzzy Rule based systems, Predicate logic, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification.

Genetic Algorithm History of Genetic Algorithms (GA), Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Convergence of GA, Bit wise operation in GA, Multi-level Optimization.

Neural Networks What is Neural Network, Learning rules and various activation functions, Single layer Perceptron, Back Propagation networks, Architecture of Backpropagation (BP) Networks, Backpropagation

Learning, Variation of Standard Back propagation Neural Network, Introduction to Associative Memory, Adaptive Resonance theory and Self Organizing Map, Recent Applications.

Backpropagation Networks GA based Backpropagation Networks (GA based Weight Determination, K - factor determination in Columns), Fuzzy Backpropagation Networks (LR type Fuzzy numbers, Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP, Application of Fuzzy BP Networks)

Linear Programming: Optimization techniques to solve the maximization and minimization problem and its application in biological problems.

Text & References:

- Introduction to Artificial Intelligence and Expert Systems by D.W. Patterson
- Artificial Intelligence: A Modern Approach - 3rd edition by Stuart Russell & Peter Norvig
- Artificial intelligence by Elaine Rich & Kevin Knight
- Principles of Artificial Intelligence by J. Nilsson, Narosa Publishing House
- S. Rajasekaran and G. A VijayalakshmiPai: Neural Network, Fuzzy Logic and Genetic
- Algorithm(Synthesis and Applications) PHI
- M. Mitchell: An Introduction to Genetic Algorithms, Prentice-Hall India.
- J.S.R. Jang, C.T. Sun and E.Mizutani: Neuro-Fuzzy and Soft Computing, PHI, Pearson Education.
- M. Ganesh: introduction to Fuzzy Sets and Fuzzy Logic, PHI.
- Timothy J. Ross: Fuzzy Logic with Engineering Applications, McGraw-Hill.
- D.E. Goldberg : Genetic Algorithms in Search, Optimization, and Machine Learning,
- Addison-Wesley.
- Z. Michalewicz: Genetic Algorithms + Data Structures = Evolution Programs, Spinger-Verlag.
- N.K. Sinha & M.M. Gupta (Eds): Soft Computing & intelligent Systems: Theory & Applications, Academic Press.

MIS401 Artificial and deep Neural network

Neural Networks Overview, Neural Network Representation, Computing a Neural Network's Output, Vectorizing across multiple examples, Explanation for Vectorized Implementation, Activation functions, Derivatives of activation functions, Gradient descent for Neural Networks, Backpropagation intuition, Random Initialization.

Binary Classification, Logistic Regression Cost Function, Gradient Descent, Derivatives, More Derivative Examples, Computation graph, Derivatives with a Computation Graph, Logistic Regression Gradient Descent, Gradient Descent on m Examples, Vectorization, More Vectorization Examples, Vectorizing Logistic Regression, Vectorizing Logistic Regression's Gradient Output, Explanation of logistic regression cost function

Deep L-layer neural network, Forward Propagation in a Deep Network, Building blocks of deep neural networks, Forward and Backward Propagation, Parameters vs Hyperparameters, What does this have to do with the brain?

large language model (LLM), Architecture of LLM, Model Size and Parameter Count, input representations, Self-Attention Mechanisms, Computational Efficiency, Decoding and Output Generation, Application such as chatGPT

Natural language processing (NLP), Natural language generation (NLG), Natural language understanding (NLU), Components (Text Normalisation, Sentence Segmentation, Tokenisation, Removal of Stopwords, Converting text to a common case, Stemming, Lemmatization). Perform text processing, Working with NLP Pipeline, Application of NLP

Convolutional Neural Network (CNN), Components of a Convolutional Neural Network, Convolution, Pooling, Kernel function, Application of CNN to vision.

Text & References:

- Deep learning: adaptive computation and machine learning, Bengio, Yoshua, Courville, Aaron, Goodfellow, Ian J
- Deep Learning: A Practitioner's Approach, J. Patterson, A. Gibson
- Neural Networks and Deep Learning: A Textbook, Charu C. Aggarwal
- Neural Networks and Deep Learning, Michael Nielsen.

(Elective papers-4)

MIS E401 Deployment of application with Distributed and Cloud computing Application

Evolution of Distributed Computing Systems, System models, issues in design of Distributed Systems, Distributed computing environment, web based distributed model, computer networks related to distributed systems and web-based protocols. Inter process Communication, Desirable Features of Good Message-Passing Systems, Issues in IPC by Message, Synchronization, Buffering, Multidatagram Messages, Encoding and Decoding of Message Data, Process Addressing, Failure Handling, Group Communication. The RPC Model, Mechanism, Client-Server Binding, Exception Handling, Security. Some Special Types of RPCs, Optimizations and Performance.

Introduction: Cloud computing definition, reference model, Characteristics, Benefits, Challenges, Distributed Systems, Virtualization, Service-oriented computing, Utility-oriented computing, Overview on computing platforms & technologies – AWS, Google AppEngine, MS Azure, Hadoop, Saleforce.com, Manjrasoft Aneka

Parallel & Distributed Computing: Parallel vs. Distributed computing, Elements of parallel computing, Parallel processing - hardware architecture & approaches, Concept & Component of Distributed Computing, RPC, Service-oriented computing

Virtualization: Cloud reference model – IaaS, PaaS, SaaS, Types of clouds – Public, Private, Hybrid, Community, Cloud interoperability & standards, scalability & fault tolerance, Security, trust & privacy

Concurrent Computing, High-throughput Computing and Data-Intensive Computing: Programming applications with Threads, Thread API, Parallel computation with Threads, Task computing, Frameworks for Task computing, Task-based application model, Data-intensive computing, characteristics, technology

Cloud Platforms and Applications: Overview on Amazon Web Services, Google AppEngine and Microsoft Azure, Cloud applications in scientific, business and consumer domain

Text & References:

- Buyya, Vecciola and Selvi, Mastering Cloud Computing: Foundations and Applications Programming, Tata McGraw Hill
- Rittinghouse and Ransome, Cloud Computing: Implementation, Management, and Security, CRC Press
- Aravind Doss, Cloud Computing, Tata McGraw Hill
- Kris Jamsa, Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business

MIS E402 Integration of Blockchain Technology

Accounting, Digital Revolution & its impact across industries, Digital Money, DigiCash, E-Gold

History & Fundamentals of Blockchain, Key Elements of Blockchain, Blockchain Protocols, Benefits of Blockchain, Types of Blockchain, Centralized vs. De-centralized systems

Cryptography, Symmetrical vs. Asymmetrical Encryption, Secure Hash Algorithms (SHA Family), Comparison of SHA functions, Digital Signatures

Consensus Mechanisms – Objectives & Need, Proof of Work (PoW), Proof of Stake (PoS), Types & Functions of Node, Construct of Block, Public vs. Private Keys

Types of Ledger, Ledgers, Distributed Ledger Technology (DLT), Benefits & Use Cases of DLT, Smart Contract

Application in Health Science

Text & References:

- Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World, 978-1101980149, 978-1260026672, Don and Alex Tapscott
- Cryptoassets: The Innovative Investor's Guide to Bitcoin and Beyon, by Chris Burniske and Jack Tatar
- The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them (Cryptography, Derivatives Investments, Futures Trading, Digital Assets, NFT) Hardcover – Illustrated, September 15, 2018, Antony Lewis,
- The Blockchain Developer: A Practical Guide for Designing, Implementing, Publishing, Testing, and Securing Distributed Blockchain-based Projects 1st ed. Edition, Apress, 978-1484248461, 2019

MIS E403 AI in Health Sciences

Introduction to Human and Artificial Intelligence: terminologies, computational models of intelligence; conceptual frameworks from cognitive and educational psychology, neuroscience, information theory, and linguistics; philosophical foundations of AI

AI in structure biology: Protein secondary structure prediction and three dimensional structure prediction, Structure prediction using alphafold

AI for medical image analysis and imaging: CNN architectures to classify 2D medical images and 3D medical imaging data. Analysis of tissue morphology and other medical imaging applications

AI for data analytics and data mining: AI data mining technologies and their application to medicine

Sequence analysis, Gene structure prediction, Finding mutation using Deepvariant, machine learning and deep learning methods for on- and off-target prediction in CRISPR/Cas9,

Survival analysis of patient: Risk stratification, patient outcome prediction, disease progression modeling

Clinical decision-making and intelligent systems to support evidence-based medicine

Phenotype and clinical/bio-marker discovery, Relevance to personalized medicine

Text & References:

- Stuart Russell and Peter Norvig. 2009. Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA.
- Toby Segaran. 2007. Programming Collective Intelligence (First ed.). O'Reilly.
- Tony J. Cleophas and Aeilko H. Zwinderman. 2015. Machine Learning in Medicine - a Complete Overview. Springer.
- Sunila Gollapudi, S. 2016. Practical Machine Learning. Packt Publishing Ltd.
- Peter Harrington. 2012. Machine Learning in Action. Manning Publications Co., Greenwich, CT, USA.
- Selected seminal and contemporary readings from peer-reviewed literature such as Proceedings of Machine Learning in Healthcare, Artificial Intelligence in Medicine, IEEE Transactions on Biomedical and Health Informatics, and other relevant venues.

MIS E404 Bigdata Tools and Technology

Big Data and its Importance Big data introduction, Structured, Semi-structured and Unstructured data, V's of Big Data, Drivers for Big Data, Introduction to Big Data Analytics, Big Data Analytics applications.

Big data technologies Bigdata technologies, distributed data processing, bigdata processing requirements, Hadoop, Components of Hadoop – The Hadoop Distributed File System, Hadoop MapReduce and Hadoop Common Components. Application Development in Hadoop – Pig, Hive, hbase. Getting Your Data into Hadoop – Basic Copy Data,. NoSQL, CAP theorem.

Integration of data warehousing and bigdata Integration of data warehousing and bigdata, components of the new data warehouse, bigdata appliances, Data Discovery and Visualization: bigdata analaytics, business problems suited for bigdata analytics, metadata, processing complexity of bigdata, Big Sheets. Advanced Text Analytics Toolkit. Machine learning Analytics, graph analytics.

Text & References:

- An Introduction to Data Science, Jeffrey Stanton, Syracuse University
- A Simple Introduction to DATA SCIENCE, Lars Nielsen, Noreen Burlingame
- Introduction to Data Science, DAN POTTER,CARSTEN BINNING,ELI UPFAL
- Big Data and Analytics, Seema Acharya , Subhashini Chellappan
- Professional Hadoop Solution, Boris Lublinsky, Kevin T. Smith, Alexey Yakubovich

MIS E405 Quantum Computing

Introduction: Elementary quantum mechanics:, linear algebra for quantum mechanics,Quantum states in Hilbert space,The Bloch sphere, Density operators, generalized measurements, no-cloning theorem.

Quantum gates and algorithms Universal set of gates, quantum circuits, Solovay-Kitaev theorem, Deutsch-Jozsa algorithm, factoring, Simon's algorithm,Period Finding Shor's Algorithm QFT (Basics), The prime factorization algorithm, Grover's search algorithm

Quantum Computation and optimization Implement quantum programs in NISQ model of computing, Current machines (5-50 qubit) What is NISQ Model?, NISQ Metrics, Qubit Mapping Problem Qubit Allocation Problem, Become familiar with Quantum Approximate Optimization Algorithm,Maxcut problem Overview of QAOA Optimizations for QAOA

Quantum error correcting codes Types of error,s Device Level, Metrics System Level, Metrics Benchmarking, Analyze software-based techniques for reducing the error rate of NISQ, Variability-Aware Mapping Diversity-Aware Mapping Reducing Measurement Errors Reducing Idling Errors

Quantum cryptography Quantum key distribution, Bell's theorem and EPR paradox

Text & References:

- Nielsen, Michael A., and Isaac L. Chuang. Quantum Computation and Quantum Information. Cambridge, UK: Cambridge University Press, September 2000. ISBN: 9780521635035.
- Preskill, J. Notes on Quantum Computation.
- Peres, Asher. Quantum Theory: Concepts and Methods. New York, NY: Springer, 1993. ISBN: 9780792325499.

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