# AMRITA VISHWA VIDYAPEETHAM

## Five Year Integrate M.Sc Data Science

## Syllabus-2018 admissions onwards

### LEARNING OUTCOMES

The design of the program was developed through discussions between the computer science and mathematics faculty and Centers for Cyber Security and CEN. Each student's plan of study should address a set of learning outcomes developed from these discussions. The learning outcomes answer the question: *"What should a graduate of our data science program be able to do?"*

- Build mathematical / statistical models and understand their power and limitations
- Design an experiment
- Use machine learning and optimization to make decisions
- Acquire, clean, and manage data
- Visualize data for exploration, analysis, and communication
- Collaborate within teams
- Deliver reproducible data analysis
- Manage and analyze massive data sets
- Assemble computational pipelines to support data science from widely available tools
- Conduct data science activities aware of and according to policy, privacy, security and ethical considerations
- Apply problem-solving strategies to open-ended questions

**18MAT101 CALCULUS 3 1 0 4**

**Unit 1**

Differentiation: The Derivative as a Function – Differentiation Rules – The Derivative as a Rate of Change – Derivatives of Trigonometric Functions – The Chain Rule and Parametric Equations – Implicit Differentiation – Linearization and Differentials.

Chapter 2- Sec: 2.1 to 2.7 and Chapter 3- Sec: 3.1 to 3.6, 3.7, Self Study - Sec: 3.7.

**Unit 2**

Application of Derivatives: Extreme values of Functions – The Mean Value Theorem – Monotonic Functions and the First Derivative Test – Concavity and Curve Sketching – Intermediate Forms and L' Hospital's Rule – Anti Derivatives.

Chapter 4- Sec: 4.1 to 4.4, 4.6 to 4.8, Self Study - Sec: 4.5

**Unit 3**

The Definite Integral – The Fundamental Theorem of Calculus – Indefinite Integrals and the Substitution Rule – Substitution and Area between Curves.

Chapter 5- Sec: 5.1 to 5.6

**Unit 4**

Techniques of Integration: Basic Integration Formulas – Integration by Parts – Integration of Rational Functions by Partial Fractions – Trigonometric Integrals – Trigonometric Substitutions – Numerical Integration – Improper Integrals.

Chapter 8: 8.1 to 8.5, 8.7,8.8, Self Study - Sec: 8.6

**Unit 5**

Application of Definite Integrals: Volumes by Slicing and Rotation about an Axis – Volumes by Cylindrical Shells – Lengths of Plane Curves – Moments and Centre of Mass – Areas of Surface of Revolution and the Theorems of Pappus – Work – Fluid Pressure and Forces.

Chapter 6 – Sec: 6.1 to 6.7

**TEXTBOOK:**

1. Finney and Thomas, "Calculus", Pearson, Eleventh Edition, 2008.

**REFERENCE BOOKS:**

1. Howard Anton, IRl Bivens, Stephens Davis, "Calculus" Wiley, 10th Edition, 2016 Reprint.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, "Calculus", 3rd Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2007.
3. James Stewart, "Calculus: Early Transcendentals", Cengage (India), 8th Edition, 2016.

**18MAT104 Linear Algebra 3 1 0 4**

**Vector Spaces**: Vector spaces - Sub spaces - Linear independence - Basis – Dimension.
**Inner Product Spaces:** Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis - Orthogonal complements - Projection on subspace - Least Square Principle.

**Linear Transformations**: Positive definite matrices - Matrix norm and condition number - QR-Decomposition - Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation - Change of basis - Nilpotent transformations - Trace and Transpose, Determinants, Symmetric and Skew Symmetric Matrices, Adjoint and Hermitian Adjoint of a Matrix, Hermitian, Unitary and Normal Transformations, Self Adjoint and Normal Transformations, Real Quadratic Forms.

**Eigen values and Eigen vectors:** Problems in Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms, Conic Sections. Similarity of linear transformations - Diagonalisation and its applications - Jordan form and rational canonical form.

**TEXT BOOKS**

1. Howard Anton and Chris Rorres, "*Elementary Linear Algebra*", Tenth Edition, John Wiley & Sons, 2010.

**REFERENCES:**

1. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.
2. Gilbert Strang, "*Linear Algebra and Its Applications*", Fourth Edition, Cengage, 2006.
3. Kenneth Hoffmann and Ray Kunze, *Linear Algebra*, Second Edition, Prentice Hall, 1971.
4. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

**18PHY101 PHYSICS 3 0 0 3**

**UNIT 1**

**Units and measurements, Vectors**: fundamentals, **Motion in One Dimension:** Displacement, Velocity, and Speed, instantaneous, velocity and speeds ,acceleration, motion diagrams, constant acceleration, varying acceleration, freely falling body, kinematic equations.

**Motion in 2D and 3D**: The displacement, Velocity and acceleration vectors,Relative velocity and Relative acceleration Two dimensional motion with constant acceleration, Projectile motion ,horizontal range and maximum height.

**UNIT 2**

**Newton's laws of motion**, inertia, torque, Newton's law of universal gravitation applications & Free body diagrams, work and Kinetic energy, potential energy and conservation of energy momentum & collisions.

**Circular motion**,uniform circular motion, Non-uniform Circular motion tangential and radial acceleration Rotational of rigid body inertia, torque, Angular momentum.

**UNIT 3**

**Kinematics of moving fluids**, equation of continuity, Euler's equation, Bernoulli's theorem, viscous fluids, surface tension and surface energy, capillarity.

**UNIT 4**

**Zeroth law of thermodynamics:** Concept of temperature & its measurement, Triple point of water, Thermometers: constant volume, Constant pressure, Platinum resistance thermometry, Thermal expansion,

**First law of thermodynamics:** Internal energy and work, Heat and Enthalpy, Heat Capacity and its measurement, Heat transfer mechanisms - Conduction, Convection, Radiation, kinetic Theory of gases, Avogadro number, Work done by an ideal gas, Molecular Speed distribution, Molar specific heat, Adiabatic, Isothermal, Constant volume Constant Pressure process for an ideal gas.

**UNIT 5**

**Second law of thermodynamics:** Kelvin Planck statements, Entropy and its variation external and internal combustion engines - Carnot engine: Steam engine, Stirling engine, Clausius statement of second law, Refrigerator, Equivalence of Kelvin-Planck and Clausius statement. Reversibility and irreversibility, Conditions for irreversibility. Irreversibility of second law of thermodynamics

***TEXTBOOK:***

*David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of Physics 9$^{th}$ Edition,John Wiley (2012){**Chapters 1-14, 18-20**}*

***REFERENCE BOOKS:***


*1. Kittel et al, Mechanics, Berkeley Physics Course Vol. 1, 2$^{nd}$ edition, Tata McGraw Hill 2011.*

*2. Raymond. A. Serway and Jerry. S. Faughn, College Physics 7$^{th}$ Ed., Thomson Brooks/Cole, USA, 2009.*

*3. Francis. W. Sears, Mark. W. Zemanski and Hugh. D. Young, University Physics, Narosa Publishing House, 2011.*

*4. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynman Lectures on Physics Vol. 1, Narosa, 2003*


**18PHY181 Physics Lab I - Mechanics and Properties of Matter**

1. Young's modulus – Uniform bending
2. Torsional Pendulum

3. Compound Pendulum
4. Coefficient of viscosity- Poiseuille's method
5. Surface tension of liquid by capillary raise method
6. Thermal conductivity of bad conductor - Lee's disc
7. Kundt's tube
8. Specific heat capacity of a liquid by method of cooling.

Text Book: Laboratory manual supplied by the Department

**18CSE 100 Problem Solving and Computer Programming 3 0 0 3**

**Unit 1**

Conceptual introduction: topics in computer science, algorithms; modern computer systems: hardware architecture, data representation in computers, software and operating system; Installing Python; basic syntax, interactive shell, editing, saving, and running a script. The concept of data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages;

**Unit 2**

Conditions, boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation. Strings and text files; manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers

**Unit 3**

Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries. Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Recursive functions. Testing, Debugging, Exceptions, Assertions. Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects

**TextBook**

1. Guttag, John. *Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition*. MIT Press, 2016. ISBN: 9780262529624.

**18CSE 180 Problem Solving Computer Programming Lab 0 0 2 1**

1. Installing Python environments
2. Using Python Interpreter to do basic operations like arithmetic computations.
3. Working with variables of different datatypes and using them in expressions.
4. Building stand alone Python scripts
5. Implementing logic requiring conditional expressions and looping
6. Working with strings using inbuilt functionalities of the datatype
7. Working with Python inbuilt datatypes like Lists, Tuples and Dictionaries
8. Working with modularity : Implementing functions and designing logic in a modular fashion
9. Implement unit testing measures assertions and exception handling
10. Use Python to model object oriented programming principles using various use cases.

**TextBook**

1. Guttag, John. *Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition*. MIT Press, 2016. ISBN: 9780262529624.

**18MAT115 VECTOR CALCULUS 3 1 0 4**

**Unit-1**

Calculus of vector-valued functions: Vector-valued functions of a real variable-Algebraic operations. Components- Limits, derivatives and integrals-Applications to curves. Tangency-Applications to curvilinear motion-Velocity, speed and acceleration-The unit tangent, the principal normal -The definition of arc length.

Vol.1, Chapter 14- Sec. 14.1 to 14.10.

**Unit-2**

Differential calculus of scalar and vector fields: Functions of $R^n$ to $R^m$.Scalar and vector fields-Open balls and open sets-Limits and continuity-The derivative of a scalar field with respect to a vector-Directional derivatives and partial derivatives-Partial derivatives of higher order-Directional derivatives and continuity-The total derivative-The gradient of a scalar field-A chain rule for derivatives of scalar fields- Applications to geometry. Level sets. Tangent planes

Vol.2, Chapter-8-Sec. 8.1 to 8.17.

**Unit-3**

Line Integrals: Introduction-Paths and line integrals-Other notations for line integrals-Basic properties of line integral-Open connected sets. Independence of paths-The second fundamental theorem of calculus for line integrals-The first fundamental theorem of calculus for line

integrals-Necessary and sufficient conditions for a vector field to be gradient-Necessary conditions for a vector field to be gradient-Special methods for constructing potential functions.

Vol.2, Chapter-10-Sec 10.1 to 10.5, 10.10 and 10.11, 10.14 to10.18.

**Unit-4**

Multiple Integrals: Introduction-Green's theorem in the plane-Some applications of Green's theorem-A necessary and sufficient condition for a two-dimensional vector field to be a gradient-Change of variables in double integral-Special cases of transformation formula.

Vol.2, Chapter-11-Sec. 11.19 to 11.22, 11.26 to 11.28.

**Unit-5**

Surface Integrals: Parametric representation of a surface-The fundamental vector product- The fundamental vector product as a normal to the surface-Surface integrals-Other notations for surface integrals-The theorem of Stokes-The curl and divergence of a vector field- Further properties of the curl and divergence-The divergence theorem (Gauss' theorem)

Vol.2, Chapter-12-Sec. 12.1 to 12.4, 12.7,12.9 to12.15, 12.19 and 12.21.

**TEXTBOOKS:**


1. Howard Anton, IRl Bivens, Stephens Davis, "Calculus" Wiley, 10th Edition, 2016 Reprint.
2. Tom M. Apostol, CalculusVolume1, John Wiley & Sons, Second edition, 2007.
3. Tom M. Apostol, Calculus Volume 2, John Wiley & Sons, Second edition, 2007.


**REFERENCE BOOKS:**


1. Howard Anton "Calculus" John Wiley and Sons
2. Murray R Spiegel, Theory and problems of vector analysis, Schaum's outline series, McGraw-Hill Book Compnay 1974.
3. Finney and Thomas , Calculus, Pearson, Eleventh Edition, 2008.


**18MAT112 Discrete Mathematics 3 0 2 4**

**Phase I**

**Logic, Mathematical Reasoning and Counting:** Logic, Prepositional Equivalence, Predicate and Quantifiers, Theorem Proving, Functions, Mathematical Induction. Recursive Definitions, Recursive Algorithms, Basics of Counting, Pigeonhole Principle, Permutation and Combinations. (Sections: 1.1 -1.3, 1.5 -1.7, 2.3, 4.1 - 4.4, 5.1 - 5.3 and 5.5)

**Phase II**

**Relations and Their Properties:** Representing Relations, Closure of Relations, Partial Ordering, Equivalence Relations and partitions. (Sections: 7.1, 7.3 - 7.6)

**Advanced Counting Techniques and Relations:** Recurrence Relations, Solving Recurrence Relations, Generating Functions, Solutions of Homogeneous Recurrence Relations, Divide and Conquer Relations, Inclusion-Exclusion. (Sections: 6.1 - 6.6)

**Phase III**

**Graph Theory:** Introduction to Graphs, Graph Operations, Graph and Matrices, Graph Isomorphism, Connectivity, Euler and Hamilton Paths, Shortest Path Problem, Planar Graph, Graph Colorings and Chromatic Polynomials. (Sections: 8.1 - 8.8)

**TEXTBOOKS:**

1. Kenneth H. Rosen, "Discrete Mathematics and its Applications", Tata McGraw- Hill Publishing Company Limited, New Delhi, Sixth Edition, 2007.

**REFERENCES:**

1. R.P. Grimaldi, "Discrete and Combinatorial Mathematics", Pearson Education, Fifth Edition, 2007.

2. Thomas Koshy, "Discrete Mathematics with Applications", Academic Press, 2005.
3. Liu, "Elements of Discrete Mathematics", Tata McGraw- Hill Publishing Company Limited , 2004.

## 18CSE 117 Digital Electronics 3 0 0 3

**UNIT I MINIMIZATION TECHNIQUES AND LOGIC GATES**

Minimization Techniques: Boolean postulates and laws – De-Morgan‟s Theorem - Principle of Duality - Boolean expression - Minimization of Boolean expressions — Minterm – Maxterm - Sum of Products (SOP) – Product of Sums (POS) – Karnaugh map Minimization – Don‟t care conditions – Quine - Mc Cluskey method of minimization. Logic Gates: AND, OR, NOT, NAND, NOR, Exclusive–OR and Exclusive–NOR Implementations of Logic Functions using gates, NAND–NOR implementations – Multi level gate implementations- Multi output gate implementations. TTL and CMOS Logic and their characteristics – Tristate gates

**UNIT II COMBINATIONAL CIRCUITS**

Design procedure – Half adder – Full Adder – Half subtractor – Full subtractor – Parallel binary adder,parallel binary Subtractor – Fast Adder - Carry Look Ahead adder – Serial Adder/Subtractor - BCD adder – Binary Multiplier – Binary Divider - Multiplexer/

Demultiplexer – decoder - encoder – parity checker – parity generators – code converters - Magnitude Comparator.

**UNIT III SEQUENTIAL CIRCUITS**

Latches, Flip-flops - SR, JK, D, T, and Master-Slave – Characteristic table and equation – Application table – Edge triggering – Level Triggering – Realization of one flip flop using other flip flops – serial adder/subtractor- Asynchronous Ripple or serial counter – Asynchronous Up/Down counter - Synchronous counters – Synchronous Up/Down counters – Programmable counters – Design of Synchronous counters: state diagram- State table –State minimization – State assignment - Excitation table and maps-Circuit implementation - Modulo–n counter, Registers – shift registers - Universal shift registers – Shift register counters – Ring counter – Shift counters - Sequence generators.

**UNIT IV MEMORY DEVICES**

Classification of memories – ROM - ROM organization - PROM – EPROM – EEPROM – EAPROM,RAM – RAM organization – Write operation – Read operation – Memory cycle - Timing wave forms – Memory decoding – memory expansion – Static RAM Cell- Bipolar RAM cell – MOSFET RAM cell – Dynamic RAM cell –Programmable Logic Devices – Programmable Logic Array (PLA) - Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA) - Implementation of combinational logic circuits using ROM, PLA, PAL

**UNIT V SYNCHRONOUS AND ASYNCHRONOUS SEQUENTIAL CIRCUITS**

Synchronous Sequential Circuits: General Model – Classification – Design – Use of Algorithmic State Machine – Analysis of Synchronous Sequential Circuits Asynchronous Sequential Circuits: Design of fundamental mode and pulse mode circuits – Incompletely specified State Machines – Problems in Asynchronous Circuits – Design of Hazard Free Switching circuits. Design of Combinational and Sequential circuits using VERILOG.

**TEXT BOOK:**

1. M. Morris Mano, “Digital Design”, 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson
Education (Singapore) Pvt. Ltd., New Delhi, 2003.

**REFERENCES:**

1. R. H. Katz and G. Boriello, Contemporary Logic Design, 2nd Ed., Prentice Hall of India, 2009.John F.Wakerly, “Digital Design”, Fourth Edition, Pearson/PHI, 2008.
2. A. P. Malvino, D. P. Leach and G. Saha, Digital Principles and Applications, 7th Ed., McGraw Hill, 2010.
3. John.M Yarbrough, “Digital Logic Applications and Design”, Thomson Learning, 2006.

**18CSE185 Digital Electronics Lab 0 0 2 1**

**List of Experiments:**

1. Realization of basic gates using Universal logic gates.
2. Code conversion circuits- BCD to Excess-3 and vice-versa.
3 Four-bit parity generator and comparator circuits.
4. Construction of simple Decoder and Multiplexer circuits using logic gates.
5. Design of combinational circuit for BCD to decimal conversion to drive 7-segment display using multiplexer.
6. Construction of simple arithmetic circuits-Adder, Subtractor.
7. Realization of RS-JK and D flip-flops using Universal logic gates.
8. Realization of Universal Register using JK flip-flops and logic gates.
9. Realization of Universal Register using multiplexer and flip-flops.
10. Realization of Asynchronous Up/Down counter.
11. Realization of Synchronous Up/Down counter.
12. Realization of Ring counter and Johnson's counter.
13. Construction of adder circuit using Shift Register and full Adder.

**18CSE116 Advanced Computer Programming 3 0 0 3**

**Unit 1**

Working with packages: How to install/import and use an external Python package. Popular Python packages for applied data science: Exercises to understand usage of libraries like Numpy, SciPy, Pandas in interpreted and script modes.

**Unit2**

Applied Plotting, Charting & Data Representation in Python: Fundamentals of data reading, streams etc and using Pandas, Basic Charting using Matplotlib, Advanced plots, interactive plots and animated plots, Plotting with Pandas, Seaborn.

**Unit 3**

Python packages for accessing the Web Data: Regex, urlib, BeautifulSoup, Json, Retrieving and parsing webpages (Json, XML), REST API, Facebook and Twitter API. Connecting DB with Python: Reading and Writing, possible simple SQL queries.

**TextBook**

1. William McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython,* Second edition (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414

**18CSE181 Advanced Computer Programming Lab 0 0 2 1**

1. Installing external packages and using them in Python scripts
2. Work with NumPy, SciPy on solving simple mathematical problems
3. Implementing functionalities in Pandas to work with tabular data and do simple database operations on them
4. Implement various plotting and charting methods using packages like Matplotlib and its abstractions like Seaborn
5. Develop Python scripts that can retrieve data from the Web and do operations like parsing, searching, and formatting using packages like BeautifulSoup, urllib, Regex
6. Implement direct database access/manipulations by using Python scripts.

**TextBook**

1. William McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython*, Second edition (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414

**18MAT232** **Probability Theory** **3 1 0 4**

**Unit – I**

Sample Space and Events, Interpretations and Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence, Bayes theorem.

**Unit – II**

Random variables, Probability Distributions and Probability mass functions, Cumulative Distribution functions, mathematical expectation, variance, moments and moment generating function.

**Unit – III**

Standard discrete distributions - Binomial, Poisson, Uniform, Geometric distributions, Negative binomial and Hypergeometric Distributions -Standard continuous distributions - Uniform, Exponential, Gamma, Beta and Normal distributions. Chebyshev's theorem.

**Unit-IV**

Two dimensional random variables-Joint, marginal and conditional probability distributions for discrete and continuous cases, independence, expectation of two dimensional random variables - conditional mean, conditional variance, covariance and correlation.

**Unit – V**

Functions of one and two random variables. Sampling and sampling Distributions- t, F and Chi-square distributions – central limit theorem.

**Textbooks:**


1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005
2. Amir D Azcel, Jayavel Sounderpandian, Palanisamy Saravanan and Rohit Joshi, Complete Business Statistics, 7th edition McGrawHill education 2012.
3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.


**Reference books:**


1. Ross S.M., *Introduction to Probability and Statistics for Engineers and Scientists*, 3rd edition, Elsevier Academic Press.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.

**18MAT231 Optimization Techniques 3 1 0 4**

**Unit I**

Introduction to optimization: classical optimization, Optimality criteria – Necessary and sufficient conditions for existence of extreme point.

Direct search methods: unidirectional search, evolutionary search method, simplex search method, Introduction, Conditions for local minimization. One dimensional Search methods: Golden search method, Fibonacci method, Newton's Method, Secant Method, Remarks on Line Search Sections. Hook-Jeeves pattern search method.

Unit II

Gradient-based methods- introduction, the method of steepest descent, analysis of Gradient Methods, Convergence, Convergence Rate. Analysis of Newton's Method, Levenberg-Marquardt Modification, Newton's Method for Nonlinear Least-Squares.

Sections 8.1 - 8.3 and 9.1 – 9.4

Unit-III

Conjugate direction method, Introduction The Conjugate Direction Algorithm, The Conjugate Gradient Algorithm for Non-Quadratic Quasi Newton method. Sections 10.1 - 10.4 and 11.1, 11.2

Unit IV

Nonlinear Equality Constrained Optimization- Introduction, Problems with equality constraints Problem Formulation, Tangent and Normal Spaces, Lagrange Condition

Sections 19.1 -19.6

Unit V

Nonlinear Inequality Constrained Optimization -Introduction - Problems with inequality constraints: Kuhn-Tucker conditions.

Sections 20.1, 20.2, 22.1 – 22.4

Text Book

1. Edwin K.P. Chong, Stanislaw H. Zak, “An introduction to Optimization”, 2nd edition, Wiley, 2013.

Reference Books

1. Mokhtar S. Bazarra, Hamit D sherali, C.M. Shetty, “Nonlinear programming Theory and applications”, 2nd edition, Wiley , 2004.
2. Mohan C. Joshi and Kannan M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, New Delhi, 2004 (Reference)

3. Kalyanmoy Deb, “Optimization for Engineering Design Algorithms and Examples”, Prentice Hall of India, New Delhi, 2004.
4. S.S. Rao, “Optimization Theory and Applications”, Second Edition, New Age International (P) Limited Publishers, 1995.

**18MAT 233 Numerical Methods 3 1 0 4**

Unit 1

Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, system of nonlinear equations.

Solution of System of Linear Algebraic Equations, Gauss-Elimination, LU Decomposition and Gauss-Seidel, Conjugate gradient method.

Eigenvalues and Eigenvectors: Jacobi Method for symmetric matrices, Power method for arbitrary matrices.

Unit 2

Interpolation and Approximation: Lagrange, Newton’s Divided Difference, Newton’s Forward and Backward interpolations and cubic splines,

Unit 3

Differentiation and Integration: Numerical differentiation, Maxima and Minima, Numerical integration, Newton-Cotes formulas, Romberg integration, Gaussian integration,

Unit 4

Solutions of Ordinary Differential Equations: Initial Value problems, Euler methods, Modified Euler method and Fourth order Runge-Kutta method. Boundary value problems using Forward Difference operators.

Unit 5

Solutions of Partial Differential equations: Elliptic, Parabolic and Hyperbolic equations implicit and explicit methods.

TEXTBOOKS:

1. Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge University Press, 2010.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.

REFERENCE BOOKS:


1. R.L. Burden, J. D. Faires, Numerical Analysis, Richard Stratton, 2011, 9th edition.
2. S.D. Conte and Carl de Boor, 'Elementary Numerical Analysis; An Algorithmic Approach'. International series in Pune and Applied Mathematics, McGraw Hill Book Co., 1980.
3. S. S. Sastry, Introductory methods of Numerical Analysis, 2012, PHI Publishers, 5th edition,


**18CSC201 Data Structures 3 1 0 4**

**Unit 1**

Abstraction - Abstract data types; Data Representation; Elementary data types; Basic concepts of data Structures; Mathematical preliminaries - big-Oh notation; efficiency of algorithms; notion of time and space complexity; performance measures for data structures. ADT array - Computations on arrays - sorting and searching algorithms.

**Unit 2**

ADT Stack, Queue, list - array, linked list, cursor based implementations of linear structures. ADT Tree - tree representation, properties traversal of trees; ADT- Binary Trees – properties and algorithms, ADT Priority Queue - Heaps; heap-based implementations; applications of heaps - sorting; Search Tree - Binary search tree; balanced binary search trees - AVL tree; Applications of Search Trees - TRIE; 2-3-4 tree; concept of B-Tree. ADT Dictionary - array based and tree based implementations; hashing - definition and application .

**Unit 3**

Graphs: ADT- Data structure for graphs - Graph traversal- Transitive Closure- Directed Acyclic graphs - Weighted graphs – Shortest Paths - Minimum spanning tree – Greedy Methods for MST.

**TEXTBOOKS:**


1. Goodrich M T, Tamassia R and Michael H. Goldwasser, “Data Structures and Algorithms in Python++”, Wiley publication, 2013.


**REFERENCES:**


1. Goodrich M T and Tamassia R, “Data Structures and Algorithms in Java”, Fifth edition, Wiley publication, 2010.
2. Tremblay J P and Sorenson P G, “An Introduction to Data Structures with Applications”, Second Edition, Tata McGraw-Hill, 2002.
3. Clifford A. Shaffer, “Data Structures and Algorithm Analysis”, Third Edition, Dover Publications, 2012.

**18CSC281 Data Structures Lab 0 0 2 1**

Implementing Sample ADT, Templates - Stacks and Queues: Array implementation, Applications - Vector, Lists, using these STLs for other implementations -Linked list: Singly and Doubly Linked Lists Implementation, Linked Stacks, D-Queue, Circular Queue - Implementing STL: Sequences, Iterators - Trees: Binary search tree, Priority Queue, Heaps - Graphs: Graph Representations, Traversals (BFS, DFS) - Hashing: Hash Table creation, creating hash functions, dynamically resizing hash tables.

**18CSC202 FOUNDATIONS OF DATA SCIENCE 2-0-2-3**

**Unit-1**

Introduction, Causality and Experiments, Data Preprocessing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of exploratory data analysis, Randomness, Probability, Introduction to Statistics, Sampling, Sample Means and Sample Sizes.

**Unit-2**

Descriptive statistics – Central tendency, dispersion, variance, covariance, kurtosis, five point summary, Distributions, Bayes Theorem, Error Probabilities; Permutation Testing, Statistical Inference; Hypothesis Testing, Assessing Models, Decisions and Uncertainty, Comparing Samples, A/B Testing, P-Values, Causality.

**Unit-3**

Estimation, Prediction, Confidence Intervals, Inference for Regression, Classification , Graphical Models, Updating Predictions.

**TEXT BOOKS**

**1.** Adi Adhikari and John DeNero, “Computational and Inferential Thinking: The Foundations of Data Science”, e-book.

**REFERENCES:**

1. Data Mining for Business Analytics: Concepts, Techniques and Applications in R, by Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, Kenneth C. Lichtendahl Jr., Wiley India, 2018.
2. Rachel Schutt & Cathy O’Neil, “Doing Data Science” O’ Reilly, First Edition, 2013.

**18MAT288 Data Science Lab-I: Statistics and Numerical Lab 0 0 2 1**

1. Data Visualization using plot, pie chart, bar chart, histogram and Box plot
2. Find the central measures for given data, like, mean, mode, median and deviations
3. Root finding
4. Gauss iteration methods
5. Power method for finding eigenvalues and eigenvectors
6. Numerical Differentiation and integrations.
7. Interpolations.
8. Initial and Boundary value problems, solution of partial differential equations.

**18MAT 241 Statistical Inference Theory 3-0-0-3**

**Unit-I**

Estimation theory - Point Estimation - Introduction- criteria of point estimation, unbiasedness, consistency, sufficiency, and efficiency of various distributions, method of maximum likelihood estimation and method of moments – minimum risk estimators.

**Unit II**

Interval Estimation: Introduction - confidence Interval for mean of a Normal Distribution with Variance known and unknown - Confidence Interval for the two means of a Normal Distribution with Variance known and unknown, Confidence interval for one and two Population Proportions , Confidence interval for the variance and ratio of variances.

**Unit-III**

Inference theory - introduction to hypothesis testing - large sample tests for single mean and two means - large sample tests for single proportion and two proportions.

**Unit-IV**

Small sample tests for single mean and two means – paired t-test - test for single variance – test for equality of two variances.

**Unit-V**

Chi-square goodness of fit for Binomial, Poisson and Normal distributions, Independence of attributes, test for homogeneity, Non-parametric tests - sign test, signed rank test and Mann-Whitney U test.

**Textbooks:**

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005

2. Amir D Azcel, Jayavel Sounderpandian, Palanisamy Saravanan and Rohit Joshi, Complete Business Statistics, 7th edition McGrawHill education 2012.
3. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.

**Reference books:**

1. Ross S.M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd edition, Elsevier Academic Press.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.

**18MAT242 Introduction to Modern Algebra 3 0 0 3**

**Unit 1:** Sets and Relations - Operations on Sets and their Properties, Partitions and Equivalence Relations, Binary Operations, Isomorphic Binary Structures - Injective and Surjective Mapping, Composition of Mappings and its Properties and Congruence Modulo of a given integer. **(Chapters 0 to 3)**

**Unit 2:** Definition and Examples of Groups, Elementary Properties of Groups, Finite Groups and Group Tables, Subgroups. Cyclic Groups, its Properties, its Structures and its Subgroups, Generating Sets. **(Chapters 4 to 7)**

**Unit 3:** Groups of Permutations, Cayley's Theorem, Orbits, Cycles, Even and Odd Permutations, Alternating Groups. Cosets, Lagrange Theorem, Direct Products of Groups, Fundamental Theorem of Finitely Generated Abelian Groups. **(Chapters 8 to 11)**

**Unit 4:** Homomorphisms, Properties of Homomorphisms, Factor Groups, Normal Subgroups, Inner Automorphisms, Factor Group Computations and Simple Groups, Center and Commutator Subgroups. **(Chapters 13 to 15)**

**Unit 5:** Definition, Examples and Properties of Rings, Homomorphisms and Isomorphisms of Rings, Fields, Integral Domains, The Characteristic of a Ring, Fermat's and Euler's Theorems, The Field of Quotients, Rings of Polynomials. **(Chapters 18 to 22)**

**TEXTBOOK:**

1. John B. Fraleigh, 'A First Course in Abstract Algebra', Seventh Edition, Pearson Education Inc. 2003.

**REFERENCES:**

1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

2. Joseph A. Gallian, 'Contemporary Abstract Algebra', Cengage Learning, 2013.

**18CSC211 CONVEX OPTIMIZATION 3 0 0 3**

**Unit 1. I**ntroduction: Mathematical optimization, Least-squares and linear programming, Convex optimization, Nonlinear optimization.

Chapter 1.

**Unit 2**

Convex sets: Affine and convex sets. Some important examples. Operations that preserve convexity. Generalized inequalities. Separating and supporting hyperplanes. Dual cones and generalized inequalities.

Chapter-2

**Unit 3**

Convex functions: Basic properties and examples. Operations that preserve convexity. The conjugate function. Quasiconvex functions. Log-concave and log-convex functions. Convexity with respect to generalized inequalities.

Chapter-3.

**Unit 4**

Convex optimization problems. Optimization problems. Convex optimization. Linear optimization problems. Quadratic optimization problems. Geometric programming. Generalized inequality constraints. Vector optimization.

Chapter-4.

**Unit 5:**

Duality: The Lagrange dual function. The Lagrange dual problem. Geometric interpretation. Saddle-point interpretation. Optimality conditions. Perturbation and sensitivity analysis. Theorems of alternatives. Generalized inequalities.

TEXT BOOKS:

1. Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press, 2009.

REFERENCES:

1. Dimitri P. Bertsekas, Convex Optimization Theory, University Press, 2016.
2. Hamdy A. Taha, “Operations Research-An Introduction”, Prentice Hall, 9th Edition, 2010.
3. Edwin K.P. Chong and Stanislaw H. Zak, “An Introduction to Optimization”, Second Edition, Wiley-Interscience Series in Discrete Mathematics and Optimization, 2004.

**18CSC212 Design and Analysis of Algorithms 3 1 0 4**

**Unit 1**

Introduction: Problem solving -- adding 2 n-bit numbers, multiplication as repeated addition. Running time analysis -- recall of asymptotic notation, big-oh, theta, big-omega, and introduce little-oh and little-omega. Worst case and average case

Basic design paradigms with illustrative examples -- incremental design (e.g., incremental sorting, interpolating polynomials), decremental design (e.g., GCD with discussion on input size, factorial), and pruning (e.g., order statistics). Divide and Conquer: Integer multiplication revisited with an efficient algorithm that motivates and leads into recurrences. Solving recurrences using recurrence trees, repeated substitution, statement of master theorem. Brief recall of merge sort and its recurrence. Median in worst case linear time.

**Unit 2**

Greedy Algorithms: Greedy choice, optimal substructure property, minimum spanning trees -- Prims and Kruskals, Dijkstras shortest path using arrays and heaps, fractional knapsack, and Huffman coding (use of priority queue). Dynamic Programming: Integral knapsack (contrasted with the fractional variant), longest increasing subsequence, edit distance, matrix chain multiplication, and independent sets in trees.

**Unit 3**

Graph Algorithms – Graph Traversal: Applications of BFS: distance, connectivity and connected components and cycles in undirected graphs. Applications of DFS: Topological sort, cycles in directed graphs, Biconnected Components and Strong Connectivity. Path algorithms: Shortest path algorithms (along with analysis) SSSP: Bellman Ford. APSP: Floyd Warshall’s. Minimum Spanning Tree (with analysis and applications).

String Matching: Boyer Moore – KMP – Rabin Karp. NP-completeness: reduction amongst problems, classes NP, P, NP-complete, and polynomial time reductions.

**Textbooks**

1. Introduction to Algorithms, by Cormen, Leiserson, Rivest, and Stein, MIT Press, Third Edition, 2009.

**References**

1. Algorithms, by Dasgupta, Papadimitrou and Vazirani, McGraw-Hill Education, 2006.
2. Algorithm Design, by Kleinberg and Tardos, Pearson, 2005.
3. Algorithm Design, by Goodrich and Tamassia, Wiley, 2001.

**18CSC213 Database Management Systems 3 1 0 4**

**Unit I**

Introduction to DBMS:Database System Vs File system, Database systems applications, Purpose of database systems - Data models. Relational models: Structure of relational databases – database schema keys – schema diagrams. Relational Query Languages – fundamental relational algebra operations – additional relational algebra operations. Introduction to SQL – Background – SQL data definition –structure of SQL queries – set operations – null values - aggregate functions – modifications to the database.

**Unit II**

Database design - overview of the design process – the entity-relationship model – constraints – entity-relationship diagrams – reduction to relation schemas - Entity-relationship design issues – weak entity sets – extended E-R features. Intermediate SQL: Nested subqueries - Join expression – Views – Transactions – integrity constraints – authorization. Advanced SQL – Accessing SQL from a program – functions and procedures – triggers.

**Unit III**

Relational database design – features of good relational designs – atomic domains and normal forms - 1NF, 2NF, 3NF, 4NF and BCNF – decomposition using functional dependencies - functional dependency theory – algorithm for decomposition -decomposition using multi-values dependencies – PJNF and DKNF. Over view of Transaction Management and Concurrency control

**Text Book:**

1) Silberschatz. A., Korth, H. F. and Sudharshan, S. “Database System Concepts”, 6th Edition, TMH, 2010

**Reference Books**

1) Elmasri, R. and Navathe, S. B. “Fundamentals of Database Systems”, 5th Edition, Addison Wesley, 2006

2) Date, C. J. “An Introduction to Database Systems”, 8th Edition, Addison Wesley, 2003.

3) Ramakrishnan, R. and Gehrke, J. “Database Management Systems”, 3rd Edition, McGrawHill, 2003.

**18CSC202 Design and Analysis of Algorithms Lab 0 0 2 1**

Implementation of common sorting algorithms – insertion sort, selection sort, quick sort, merge sort, bucket sort, radix sort. Greedy – task scheduling, fractional knapsack and other applications. Divide and Conquer – Closest Pair, Integer multiplication, other applications. Dynamic Programming – matrix chain multiplication, 0-1 knapsack, longest common subsequence, maximum contiguous subarray, edit distance. Graphs- minimum spanning tree algorithms, shortest path algorithms. String matching – KMP, Boyer Moore.

**18MAT289 Data Science Lab –II: Inference Theory 0 0 2 1**

1. Modern Algebra:
    - Problems in Set Theory
    - Verification of different relations (equivalence and partial order relations)
    - Problems in permutation groups

2. Inference Theory:
    - Discrete and Continuous distribution
    - Correlations
    - Testing of hypothesis

**18CSC301 OPERATING SYSTEMS 3 0 2 4**

**Unit 1**

Introduction to Operating Systems: Overview - Types of systems - Computer system operations - Hardware Protection - Operating systems services - System calls - System structure - Virtual machines. Process Management: Process concepts- Process scheduling - Operations on Process - Cooperating process - Interprocess communication - Multithreading models - Threading issues - Thread types - CPU scheduling –scheduling algorithms.

**Unit 2**

Process Synchronization: Critical section problem - synchronization hardware – Semaphores - Classical problems of synchronization - Critical regions – Monitors- Deadlocks - Deadlock characterization - Methods of handling deadlocks - Deadlock prevention – Avoidance - Detection and recovery.

**Unit 3**

Storage Management: Memory management – Swapping - Contiguous memory allocation. Paging – Segmentation - Segmentation with Paging - Virtual memory - Demand paging - Process creation – page replacement - Thrashing. File Systems: Directory structure - Directory implementation - Disk scheduling. Case study: Threading concepts in Operating systems, Kernel structures.

**TEXTBOOK:**


1. Silberschatz and Galvin, “Operating System Concepts”, Ninth Edition, John Wiley and Sons, 2012.


**REFERENCES:**


1. Deitel. Deitel and Choffnes, “Operating System”, Third edition, Prentice Hall, 2003.
2. Tannenbaum A S, “Modern Operating Systems”, Third edition, Prentice Hall, 2007.
3. Stevens W R and Rago S A, “Advanced Programming in the Unix Environment”, Second Edition, Addison-Wesley, 2013.
4. Gary Nutt, “Operating Systems”, Third Edition, Pearson Education, 2009.


**18MAT331 TRANSFORM TECHNIQUES 3 0 0 3**

Fourier series, Complex Form of Fourier Series, Parseval’s Identity, Fourier Integrals, Fourier Integral theorem. Sine and Cosine Integrals. Sine and Cosine Transforms, Properties, Convolution theorem and Parseval’s theorem**.**
(Text Book 2: Sections: 11.1, 11.2, 11.7, 11.9)

Laplace Transforms, Inverse Transforms, Properties, Transforms of Derivatives and Integrals, Second Shifting Theorem, Unit Step Function and Dirac-Delta Function, Differentiation and Integration of Transforms.
(Text book 2: Sections: 6.1, 6.2, 6.3, 6.4)

Introduction to DFT and FFT. Z-Transform: Simple properties.

**TEXTBOOK**

1. Robert G. Bartle and Donald R. Sherbert, "Introduction to Real Analysis", John Wiley and Sons, Third Edition,2000.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, Tenth Edition, 2016.

**REFERENCE BOOKS**

1) LokenathDebnath, Dambaru Bhatta, Integral Transforms and their Applications, CRC Press, Taylor &Fransis Group, Boca Raton, Third Edition, 2015.
2) Abdul J. Jerri, Integral and Discrete Transforms with Applications and Error Analysis, Monographs and text books in Pure and Applied Mathematics, Marcel Dekker,1992.
3) Joel L. Schiff, The Laplace Transform: Theory and Applictions, Springer-Verlag, Newyork, 1999.

**18CSC302 Number Theory and Information Security 3 1 0 4**

**Algorithms for integer arithmetic:** Divisibility, GCD, modular arithmetic, modular exponentiation, Montgomery arithmetic, congruence, Chinese remainder theorem, orders and primitive roots, quadratic residues, integer and modular square roots, prime number theorem, continued fractions and rational approximations.

**Representation of finite fields:** Prime and extension fields, representation of extension fields, polynomial basis, primitive elements, normal basis, optimal normal basis, irreducible polynomials, Root-finding and factorization algorithm, Lenstra-Lenstra-Lovasz algorithm.

**Elliptic curves:** The elliptic curve group, elliptic curves over finite fields, Schoof's point counting algorithm.

**Primality testing algorithms:** Fermat Basic Tests , Miller–Rabin Test , AKS Test.

**Integer factoring algorithms:** Trial division, Pollard rho method, p-1 method, CFRAC method, quadratic sieve method, elliptic curve method.

**Computing discrete logarithms over finite fields:** Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method, index calculus methods, linear sieve method, Coppersmith's algorithm.

**Quantum Computational Number Theory :** Grover's algorithm, Shor's algorithm

Applications in Algebraic coding theory and cryptography.

**TEXT BOOKS/REFERENCES:**


1. Yan, Song Y. *Computational Number Theory and Modern Cryptography*. John Wiley & Sons, 2012.
2. Meijer, Alko R. *Algebra for Cryptologists*. Springer, 2016
3. Lidl, Rudolf, and Harald Niederreiter. *Introduction to finite fields and their applications*. Cambridge university press, 1994.
4. Apostol, Tom M. *Introduction to analytic number theory*. Springer Science & Business Media, 2013.


**18MAT332 Random Processes 3 0 0 3**

Unit – I Introduction to Probability and Stochastic Processes:

Definition of Stochastic Processes, specification of Stochastic processes, Stationary processes– Markov Chains: definition and examples, higher transition probabilities, Generalization of Independent Bernoulli trails, classification of states and chains.
(Sections: 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4)

Unit – II Markov Processes with Discrete State Space:
Poisson process, Poisson process related distributions, properties of Poisson process, Generalizations of Poisson Processes, Birth and death processes, continuous time Markov Chains. (Sections: 4.1, 4.2, 4.3, 4.4, 4.5)

Unit – III Markov processes with continuous state space:

Brownian motion – Wiener Process - Differential equations for a Wiener process – Kolmogorov equations – first passage time distribution for Wiener process – Ornstein-Uhlenbech process.
(Sections: 5.1 to 5.6)

Unit – IV Renewal processes and theory:

Renewal process – Renewal processes in continuous time – Renewal equation – stopping time – Wald's equation – Renewal theorems.
(Sections: 6.1 to 6.5)

Unit – V Branching Processes:

Introduction, properties of generating functions of Branching process, Distribution of the total number of progeny, Continuous-Time Markov Branching Process, Age dependent branching process: Bellman-Harris process.
(Sections: 9.1, 9.2, 9.4, 9.7, 9.8)

Text Book:

1. J. Medhi, "Stochastic Processes", 2nd Edition, New Age International Private limited, 2006.

Book for Reference:

1. Sheldon M. Ross, "Stochastic Processes", 2ndEdition, Wiley, 1995.
2. J. Ravichandran, "Probability and Random Processes for Engineers", 1st Edition, IK International, 2015.

**18CSC303 Database Design 3-1-0-4**

**Unit 1**

Overview of DBMS – Database design – Record Oriented File Systems – File Structures, Indexing and Hashing – Disk Storage, Basic File Structures and Hashing – Indexing Structures – Single and Multi-level indexes. Query Processing Optimization and Database Tuning: - Algorithms for Query Processing and Optimization- Physical Database Design and Tuning

**Unit 2**

Transactions Processing and Concurrency Control : Transaction Concept, Transaction model, Storage Structure, Transaction Atomicity and Durability, Transaction Isolation, Serializability

Concurrency control : Lock-based protocols – Timestamp Ordering based control – Multiversion concurrency control – Locks, Database Recovery Techniques

**Unit 3**

Advanced Topics: Object Oriented, Object Relational Databases, XML Databases – Concepts, Models and Standards. Parallel and Distributed Databases, NoSQL Databases, Database Security –Introduction, Attacks and Techniques for Mitigation, Spatio-temporal and Multimedia Databases

**TEXT BOOKS**

1. Ramesh Elmasri and Shamkant B Navathe, “Fundamentals of Database Systems”, Fifth Edition, Pearson Educaton India, 2008.

**REFERENCES**

1. Silberschatz A, Korth H F and Sudharshan S, “Database System Concepts”, Sixth Edition, Tata McGraw-Hill Publishing Company Limited, 2010.
2. Niall O’Higgins, “MongoDB and Python”, O’reilly, 2011.
3. Hector Garcia-Molina, Jeff Ullman and Jennifer Widom, “Database Systems: The Complete Book”, Pearson, 2011.
4. Raghu Ramakrishnan and Johannas Gehrke, “Database Management Systems”, Third Edition, McGraw-Hill, 2003.

**18CSC381 Database Management Systems Lab 0 0 2 1**

1) Working with objects using SQL for the following
i. Data definition language: create, alter, grant, revoke, drop, truncate.
ii. Data manipulation language: select, insert, update, delete.
iii. Transaction control statements: commit, rollback, savepoint.

2) Constraints – Queries: Simple selection, projection and selection with conditions.
3) Functions: aggregate functions, group by, order by, date and conversion functions.

4) Set operators, joins, sub query: simple, nested, correlated, existence test, membership test, DDL and sub queries and DML and sub queries.

5) Working with other schema objects: view, sequence, index, synonym, cluster, lock, BLOB, CLOB, nested table, type.

6) PL/SQL programs, cursors, functions, procedures, packages, triggers, exception handling.

7) Front end tool: form creation, validation, trigger and report generation.

8) Mini Project.

**18MAT333 Graph Analytics and Algorithms 3 0 2 4**

**Unit 1**

**Review of Graphs:** Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.

**Trees:** Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees, DFS, BFS algorithms.

**Unit 2**

**Connectivity:** Graph connectivity, k-connected graphs and blocks.

**Euler and Hamilton Graphs:** Euler graphs, Euler's theorem. Fleury's algorithm for Eulerian trails. Hamilton cycles, Chinese-postman problem, approximate solutions of traveling salesman problem. Closest neighbour algorithm.

**Unit 3**

**Matching:** Matchings, maximal matchings. Coverings and minimal coverings. Berge's theorem, Hall's theorem, Tutte's perfect matching theorem, Job assignment problem and matching algorithms.

**Unit 4**

**Colorings**: Vertex colorings, greedy algorithm and its consequences, Brooks' theorem. Vertex coloring algorithm. Planar graphs. Euler theorem on planar graphs.

**Unit 5**

**Graph Networks and Centralities**: Graph Networks. Network topologies. Degree and distance centralities. Clustering centrality. Closeness centrality. Betweeness centrality.

***TEXTBOOKS***


1. *J.A. Bondy and U.S.R. Murty, Graph Theory and Applications, Springer, 2008.*
2. Mohammed Zuhair Al-Taie, Seifedine Kadry, *Python for Graph and Network Analysis, Springer, 2018.*


***REFERENCES BOOKS***


1. *Barabasi and Pasfai, Network Science, Cambride University press, 2016.*
2. *Meghanathan Natarajan, Centrality Metrics for Complext Networks Analysis, IGI publisher, 2018.*
3. *Frank Harary, Graph Theory, New York Academy of Sciences, 1979.*
4. *Graph Algorithms in Neo4j*


**18MAT334 Regression Analysis 3 1 0 4**

**Unit I**

Simple Linear Regression: Linear Regression Model, Least square estimation of the parameters, Hypothesis Testing on the slope and intercept, Interval estimation in Simple linear Regression, Prediction of New Observations and Coefficient of Determination.

**Unit II**

Multiple Linear Regression: Multiple Linear Regression Models, Estimation of the Model Parameters, Hypothesis testing in Multiple Linear Regression, Confidence Interval on the Regression and Prediction of New observations.

**Unit III**

Generalized linear models - Logistic regression Models, Poisson regression - hypothesis testing on model parameter. Model Adequacy Checking: Introduction, Residual Analysis, Detection, treatment of Outliers and Lack of fit of the Regression Model.

**Unit IV**

Polynomial regression models – polynomial models in one variable – Polynomial models in two or more variables – variable selection and model building – computational techniques for variable selection.

**Unit V**

Introduction to analysis of variance- one way and two way ANOVA – Analysis of variance in Regression: Response surface designs – Introduction to response surface methodology, Method of steepest accent, Analysis of second order response surface, experimental design for fitting response surfaces.

**Text Books/References:**


1. Douglas C. Montgomery and Elizabeth A.Peck and G.Geoffrey Vining, Introduction to Linear Regression Analysis",3rd Edition ,John Wiley& Sons, Inc
2. Douglas C. Montgomery,Design and analysis of Experiments, 8th edition, John Wiley& Sons, Inc
3. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012


**18CSC313 THEORY OF COMPUTATION 3 1 0 4**

**Unit 1**

Automata and Languages: Chomsky hierarchy of languages, Introduction Finite Automata - Regular Expressions - Nondeterministic Finite Automata - equivalence of NFAs and DFAs – Minimization of DFA.

**Unit 2**

Regular Expressions - Non-Regular Languages - Pumping Lemma for regular languages.

**Unit 3**

Parse tree derivations (top-down and bottom-up) Context free languages –Chomsky normal form, GNF - Push Down Automata - Pumping lemma for context free language. CYK Algorithm, Deterministic CFLs. Ambiguous grammar, removing ambiguity, Computability

Theory: Turing Machines - Non-deterministic Turing Machines –CSG, Undecidability - PCP Computation histories – Reducibility.

***TEXTBOOK:***

1. *Linz P, "An Introduction to Formal Languages and Automata", Fourth Edition, NarosaPublishing House, 2009*

***REFERENCES:***


1. *Michael Sipzer, "Introduction to the Theory of Computation", Third Edition, Cengage Learning, 2012.*
2. *Martin and John, "Introduction to Languages and the Theory of Computation", New York, McGraw Hill, 2002.*
3. *Garey, Michael and Johnson D S, "Computers and Intractability: A Guide to theTheory of NP-Completeness", New York, W.H. Freeman and Company, First Edition, 1979.*
4. *J E Hopcroft, R Motwani and J D. Ullman, "Introduction to Automata Theory, Languages, and Computation", Third Edition, Addison-Wesley, 2007.*


**18CSC311 Machine Learning 3 0 2 4**

Supervised Learning (Regression/Classification) : Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naïve Bayes. Linear models: Linear Regression, Logistic Regression, Generalized Linear Models. Support Vector Machines, Nonlinearity and Kernel Methods. Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: PCA and kernel PCA. Matrix Factorization and Matrix Completion. Generative Models (mixture models and latent factor models)

Assorted Topics: Evaluating Machine Learning algorithms and Model Selection. Introduction to Statistical Learning Theory. Ensemble Methods (Boosting, Bagging, Random Forests). Sparse Modeling and Estimation. Modeling Sequence/Time-Series Data. Deep Learning and Feature Representation Learning. Scalable Machine Learning (Online and Distributed Learning). A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference.

Text books/ Reference books.


1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)

3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Hal Daumé III, A Course in Machine Learning, 2015 (freely available online).

**18CSC312 DATA VISUALIZATION 3 0 0 3**

**Unit 1**

Introduction to Data Visualization – Classification of Visualization techniques – Structure and representation – Selection of a Visualization – Visualizations for high dimensional data – Graphics and computing.

**Unit 2**

Principles of Data Visualization : Multivariate data – Linked data – Visualizing trees and forests – Large Datasets – Plots and their variates – Visualizing cluster analysis – contingency tables – finite mixture models.

**Unit 3**

Methodologies: Visualization in Bayesian data analysis – Matrix visualization – Data visualization by kernel machines .Applications : Visualization for genetic network reconstruction, medical images, financial dataset and Insurance risk processes.

**TEXTBOOK**

1. Usama Fayyad, Georges G. Grinstein and Andreas Wierse, “Information visualization in Data Mining and Knowledge discovery”, Morgan kaufmann publishers, 2002

2. Chun-houh Chen, Wolfgang Hardle and Antony Unwin,”Handbook of Data Visualization”, Springer, 2008

**18CSC314 Ethics for Data Scientists 1 0 0 1**

**18CSC383 Machine Learning Lab 0 0 2 1**

**18CSC401 Parallel and Distributed Systems 3 1 0 4**

**Unit 1**

Introduction – parallelism and goals, parallel computing models – RAM, PRAM , CTA. Reasoning about Performance – Introduction -Basic Concepts - Performance Loss - Parallel Structure - Measuring Performance. Shared memory architecture.

**Unit 2**

Parallel Programming: Task and Data Parallelism with examples –Comparison Programming with Threads - POSIX Threads- Thread Creation and Destruction. Mutual Exclusion-Synchronization - Safety and Performance Issues – Reduction – threads Inter process communication – internet protocols – multicast communication – MPI. Remote invocation:Remote procedure call – remote method invocation -

**Unit 3**

System models : physical models, architecture models, operating system support. Distributed file systems – introduction- time and global states – synchronization of physical clocks – coordination and agreements: Mutual exclusion, election, consensus.

**Text Books**

1. George Coulouris , Jean Dollimore , Tim Kindberg , Gordon BlairDISTRIBUTED SYSTEMS Concepts and Design Fifth Edition , Addison Wiley, 2012.
2. Calvin Lin ,Larry Snyder, Principles of Parallel Programming, Pearson, 2009

**References**

1. Bertil Schmidt, Jorge Gonzalez-Dominguez, Christian Hundt , Moritz Schlarb, Parallel Programming: Concepts and Practice 1st Edition, Morgan Kaufmann, 2017.
2. Ajay D. Kshemkalyani, MukeshSinghal , Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press, 1 edition, 2008.

**18CSC402** **Deep Learning** **3 0 0 3**

- Basics: Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.
- Feedforward Networks: Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, autoencoders.
- Deep Neural Networks: Difficulty of training deep neural networks, Greedy layerwise training.
- Better Training of Neural Networks: Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).
- Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs

- Convolutional Neural Networks: LeNet, AlexNet.
- Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines.
- Recent trends: Variational Autoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning
- Applications: Vision, NLP, Speech (just an overview of different applications in 2-3 lectures)

Textbook:

1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016.

References:

1. Ian Goodfellow, YoshuaBengio and Aaron Courville, Deep Learning, MIT press 2016
2. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996
3. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

**18CSC404 Reinforcement Learning 3 0 0 3**

Introduction: Reinforcement Learning, Elements of Reinforcement Learning, Limitations and Scope, An Extended Example- Tic-Tac-Toe.
Multi-armed Bandits: A k-armed Bandit Problem , Action-value Methods, The 10-armed Testbed, Incremental Implementation, Tracking a Nonstationary Problem, Optimistic Initial Values, Upper-Confidence-Bound Action Selection, Gradient Bandit Algorithms.
Finite Markov Decision Processes: The Agent–Environment Interface, Goals and Rewards, Returns and Episodes , Unified Notation for Episodic and Continuing Tasks, Policies and Value Functions, Optimal Policies and Optimal Value Functions, Optimality and Approximation.
Review of Markov process and Dynamic Programming.
Temporal-Difference Learning: TD Prediction, Advantages of TD Prediction Methods, Optimality of TD, Sarsa: On-policy TD Control, Q-learning: Policy TD Control. Expected Sarsa. Maximization Bias and Double Learning.
Te**xt Book:**

**1.** Richard S. Sutton and Andrew G. Barto, Reinforcement Learning:An Introduction, MIT Press, 2018.

References:

**1.** Sudharsan Ravichandiran, Hand-on Reinforcement Learning with Python, Packt Publications, 2018.

**2.** Sayon Dutta, Reinforcement Learning with Tensor Flow: A beginner's guide, Packt Publications, 2018.

**18CSC403 Practical Techniques for Big Data Analytics 3 0 2 4**

**Unit 1**

Introduction to Big Data: Types of Digital Data-Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment - Coexistence. Big Data Analytics: Classification of analytics - Data Science - Terminologies in Big Data - CAP Theorem - BASE Concept. NoSQL: Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vs NewSQL. Introduction to Hadoop: Features – Advantages – Versions - Overview of Hadoop Eco systems - Hadoop distributions - Hadoop vs. SQL – RDBMS vs. Hadoop - Hadoop Components – Architecture – HDFS - Map Reduce: Mapper – Reducer – Combiner – Partitioner – Searching – Sorting - Compression. Hadoop 2 (YARN): Architecture - Interacting with Hadoop Eco systems.

**Unit 2**

No SQL databases: Mongo DB: Introduction – Features - Data types - Mongo DB Query language - CRUD operations – Arrays - Functions: Count – Sort – Limit – Skip – Aggregate - Map Reduce. Cursors – Indexes - Mongo Import – Mongo Export. Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL - Alter commands - Import and Export - Querying System tables.

**Unit 3**

Hadoop Eco systems: Hive – Architecture - data type - File format – HQL – SerDe - User defined functions - Pig: Features – Anatomy - Pig on Hadoop - Pig Philosophy - Pig Latin overview - Data types - Running pig - Execution modes of Pig - HDFS commands - Relational operators - Eval Functions - Complex data type - Piggy Bank - User defined Functions - Parameter substitution - Diagnostic operator.

***TEXTBOOK:***

*Seema Acharya, Subhashini Chellappan, "Big Data and Analytics", Wiley Publication, 2015.*

***REFERENCES:***


1. *Judith Hurwitz, Alan Nugent, Dr. Fern Halper, Marcia Kaufman, "Big Data for Dummies", John Wiley & Sons, Inc., 2013.*
2. *Tom White, "Hadoop: The Definitive Guide", O'Reilly Publications, 2011.*
3. *Kyle Banker, "Mongo DB in Action", Manning Publications Company, 2012.*
4. *Russell Bradberry, Eric Blow, "Practical Cassandra A developers Approach", Pearson Education, 2014.*


**18CSC405 Data Security 3 0 0 3**

**Unit1**

Access control mechanisms in general computing systems; Authentication and authorization mechanisms- Passwords (Single vs Multifactor), Captcha, Single Sign-on- Oauth and Openid connect, Authentication Protocols (Kerberos, X.509).

**Unit 2**

Malwares and its protection mechanisms- Viruses, Worms, Trojans, Ransomware, Polymorphic malware, Antivirus, Firewall and Intrusion detection systems.

**Unit3**

Networking Basics, Web, Email, and IP Security- SSL, TLS, WEP, SET, Blockchain, PGP, IPSEC.

**Unit4**

Image Processing Basics, Digital Watermarking, Steganography and Visual Cryptography.

**Unit 5**

Database System Basics, Database Security- Database watermarking, Statistical inferencing in databases, Private information retrieval, Privacy in data publishing, SQL Injection, Spark Security.

**Textbook:**


1. Mark Stamp, "Information Security: Principles and Practice", Wiley Publishing, 2nd edition, 2011
2. Behrouz A. Forouzan and Debdeep Mukhopadhyay, "Cryptography and Network Security", Tata McGraw-Hill Education Pvt. Ltd., 2nd edition, 2010


**References:**


1. Alfred Basta and Melissa Zgola, "Database Security", Cengage Learning India Pvt. Ltd., 1st edition, 2014.

2. Shivendra Shivani, Suneeta Agarwal and Jasjit S. Suri, “Handbook of Image-based Security Techniques”, Taylor and Francis, 1st edition, 2018.
3. Michael Gertz, “Handbook of Database Security: Applications and Trends”, Springer, 2008 edition.
4. Antony Lewis, “The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them”, Mango Media, 2018.
5. Prabath Siriwardena, “Advanced API Security: Securing APIs with OAuth 2.0, OpenID Connect, JWS, and JWE”, Apress, 1st edition, 2014.
6. Romeo Kienzler, “Mastering Apache Spark 2.x”, Packt Publishing Limited; 2nd Revised edition, 2017.

**18CSC406 Software Engineering 3 1 0 4**

Software process and lifecycle: Software Product, Software Processes, Study of different process models, Project Management Concepts, Planning and Scheduling, Team organization and people management.
Software requirement engineering: Software requirements, extraction and specification, Feasibility Studies, Requirements Modeling, object oriented analysis.
Design Concepts: Object oriented design, Architectural design. Component level Design, User Interface Design, Distributed Systems Architecture, Real Time Software Design, User Interface Design, Pattern Based Design.
Risk Management: Metrics and Measurement, Estimation for software projects, software configuration management, Maintenance and Reengineering.
Software Testing: Unit testing, integration testing, black box and white box testing, regression testing, performance testing, object oriented testing. Verification and validation of Software:Software Inspections and Audit, Automated Analysis, Critical systems validation.
Software Quality Assurance, Quality Standards, Quality Planning and Control, Various Quality models. Overview of recent trends in Software Engineering, Security Engineering, Agile Methods, Service Oriented Software Engineering, Aspect Oriented Software Development.Self-Study:

Text Books: 1.Ian Sommerville, Software Engineering, Addison – Wesley
References:
1.Roger Pressman, Software Engineering A Practitioners Approach, McGraw Hill Publication
2.Rajib Mall, Fundamentals of Software Engineering, Prentice Hall of India
3.Ivar Jacobson, Object Oriented Software Engineering A use case Approach, Pearson

**18CSC407 Deep Learning for Natural Language Processing 3 0 2 4**

Introduction: Words – Morphology and Finite State transducers - Computational Phonology and Pronunciation Modelling - Probabilistic models of pronunciation and spelling – Ngram Models of syntax - Hidden markov models and Speech recognition - Word classes and Part of Speech Tagging.

Context free Grammars for English – Parsing with Context free Grammar – Features and unification - Lexicalized and Probabilistic Parsing -Language and Complexity. Semantics: Representing meaning - Semantic analysis - Lexical semantics - Word sense disambiguation and Information retrieval.

Pragmatics: Discourse - Dialog and Conversational agents - Natural language generation, Statistical alignment and Machine translation: Text alignment – word alignment – statistical machine translation.

***TEXTBOOK:***

*Daniel and Martin J H, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 2009.*

***REFERENCES:***

1. *Manning C D and Schutze H, "Foundations of Statistical Natural Language processing", First Edition, MIT Press, 1999.*
2. *Allen J, "Natural Language Understanding", Second Edition, Pearson Education, 2003.*

**18CSC441 Soft Computing 3 1 0 4**

**Unit I**

Artificial Intelligence (*AI*): A Brief review – Pitfalls of Traditional *AI*–Why computational intelligence (*CI*) ? – Concepts of *CI* – Importance of tolerance of imprecision and uncertainty– Constituent techniques of *CI*– overview of Artificial Neural Networks, Fuzzy Logic, Evolutionary Computation.

**Unit II**

Fuzzy Logic:Introduction – the case of imprecision, the utility and limitation of fuzzy systems. Classical sets and Fuzzy sets: operations, properties and mapping.

**Unit III**

Classical relations and fuzzy relations: cardinality, operations, properties and composition – tolerance and equivalence relations. Properties of membership function, fuzzification and defuzzification. Logic and fuzzysystems. Fuzzy control systems – Aircraft landing control problems.

**Unit IV**

Evolutionary computation: Introduction – Constituent algorithms - Using Genetic Algorithm for solving simple optimization problems. Swarm intelligence algorithms – Overview of other bio-inspired algorithms – Over view of Hybrid approaches (neural networks, fuzzy logics, genetic algorithm etc).

**Text Books:**


1) Kumar S. 'Neural Networks – A classroom approach', TMH, 20014.
2) Ross T J 'Fuzzy Logic with Engineering Applications', TMH, 2002.
3) Eiben A E and Smith J E, ' Introduction to Evolutionary Computing', Second Edition, Springer, Natural Computing Series, 20017.


**Reference Books:**


1) Konar A, 'Computational Intelligence : Principles, Techniques and Applications", Springer Verlat, 2005.
2) Engelbercht AP, 'Fundamentals of Computational Swarm Intelligence', John Wiley and Sons , 2005.
3) Jang J S R and Sun C T ,Mizutani E, 'Neuron – Fuzzy and Soft Computing' , PHI, 2002.
4) Rajasjekaran S and VijayalakshmiPai G A 'Neural Networks, Fuzzy Logic and Genetic Algorithm', PHI, 2003.


**18CSC442 Cryptography 3 0 0 3**

**Stream ciphers:** Pseudo-random generators, Attacks on the one time pad, Linear generators, Cryptanalysis of linear congruential generators, The subset sum generator.

**Block ciphers:** Pseudorandom functions and permutations (PRFs and PRPs), PRP under chosen plaintext attack and chosen ciphertext attack, Case study: *DES, AES, modes of operation*.

**Message integrity:** Cryptographic hash functions, message authentication code, CBC MAC and its security, Cryptographic hash functions based MACs, Authenticated Encryption-Authenticated encryption ciphers from generic composition.

**Public key encryption:** RSA, Rabin, Knapsack cryptosystems, Diffie-Hellman key exchange protocol, ElGamal encryption, Elliptic curve cryptography.

**Digital signatures:** RSA, ElGamal and Rabin's signature schemes, blind signatures.

**Entity authentication:** Passwords, challenge-response algorithms, zero-knowledge protocols.

**Network security:** Certification, public-key infra-structure (PKI), secure socket layer (SSL), Kerberos.

**TEXT BOOKS/REFERENCES:**


1. A. J. Menezes, P. C. V. Oorschot and S. A. Vanstone, *Handbook of Applied Cryptography*, CRC Press, 1996.
2. J. Katz and Y. Lindell, *Introduction to Modern Cryptography*, Chapman & Hall/CRC, 2007.
3. Abhijit Das and Veni Madhavan C. E., *Public-Key Cryptography: Theory and Practice*, Pearson Education India, 2009.
4. Stinson, Douglas R. *Cryptography: theory and practice*. Chapman and Hall/CRC, 2005.
5. Dan Boneh and Victor Shoup, *A Graduate Course in Applied Cryptography*,V4, 2017

**18CSC444 DEEP LEARNING FOR IMAGE PROCESSING 3 0 0 3**

**Unit1**

Mathematical Background for Image Processing: Review of Vectors and Matrices - Review of Probability and statistics. Digital Image Fundamentals: Elements of Visual Perception- Image Sensing and Acquisition – Image Sampling and Quantization – Basic Relationships between Pixels- Image interpolation. Intensity Transformations and Spatial Filtering: Basic Intensity transformation Functions – Histogram Processing – Fundamentals of Spatial Filtering – Smoothing and Sharpening Spatial Filters.

**Unit2**

Filtering in Frequency Domain: 2D Discrete Fourier Transforms - Basics of filtering - Image Smoothing and Image Sharpening Using Frequency Domain Filters- Selective Filtering, Image Restoration: Noise Models – Restoration using Spatial Filters – Periodic Noise Reduction by Frequency Domain Filters.

**Unit 3**

Morphological Image Processing: Erosion – Dilation – Opening – Closing – Hit-or-Miss Transform- Extraction of Connected Components. Image Segmentation: Fundamentals – Point, Line and Edge Detection – Thresholding- Region Based Segmentation – Region Growing – Region Splitting and Merging. Color image processing.

***TEXTBOOK:***

*Gonzalez R C and Woods R E, "Digital Image Processing", Third Edition, Pearson Education, 2009.*

***REFERENCES:***


1. *Pratt W K, "Digital Image Processing", Fourth Edition, John Wiley & Sons, 2007.*
2. *Castleman K R, "Digital Image Processing", Prentice Hall, 1996.*
3. *Gonzalez, Woods and Eddins, "Digital Image Processing Using MATLAB", Prentice Hall, 2004.*
4. *Russ J C, "The Image Processing Handbook", CRC Press, 2007.*


**18CSC446 Mining of Massive Datasets 3 0 0 3**

Basics of Data Mining - Computational Approaches - Statistical Limits on Data Mining - Bonferroni's Principle - MapReduce - Distributed File Systems . MapReduce . Algorithms Using MapReduce . Extensions to MapReduce. Finding Similar Items - Applications of Near-

Neighbor Search - Shingling of Documents - Similarity-Preserving Summaries of Sets - Locality-Sensitive Hashing for Documents - Distance Measures
Mining Data Streams: The Stream Data Model - Sampling Data in a Stream - Filtering Streams. Link Analysis: PageRank - Efficient Computation of PageRank - Topic-Sensitive PageRank - Link Spam. Frequent Itemsets : The Market-Basket Model - Market Baskets and the A-Priori Algorithm - Handling Larger Datasets in Main Memory. Clustering: Introduction to Clustering Techniques - Hierarchical Clustering - K-means Algorithms – CURE algorithm.
Recommendation Systems: A Model for Recommendation Systems - Content-Based Recommendations - Collaborative Filtering - Dimensionality Reduction. Mining Social-Network Graphs: Social Networks as Graphs - Clustering of Social-Network Graphs - Direct Discovery of Communities - Partitioning of Graphs - Finding Overlapping Communities – Simrank. Dimensionality Reduction: Eigenvalues and Eigenvectors of Symmetric Matrices- Principal-Component Analysis - Singular-Value Decomposition . Large-Scale Machine Learning - Machine-Learning Model - Perceptrons - Support-Vector Machines .
Text Book
Jure Leskovec , Anand Rajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2014.

References

Tom White, Hadoop: The Definitive Guide: Storage and Analysis at Internet Scale , O'Reilly Media; 4 edition , 2015.

**18CSC447 Data Compression 3 0 0 3**

**Unit 1**

Information Theory Foundation: Entropy, its properties, conditional entropy, mutual information, Types of codes, Krafts McMillan Inequality theorem, Source coding theorem.Introduction to Compression Techniques: Introduction, Types of compression - Lossy, lossless. Performance measures, Modeling, Coding. Text Compression: Huffmann - static and dynamic, application in text compression, Shannon Fano Elias Coding, Arithmetic coding, Dictionary based coding-static, adaptive, UNIX compress.

**Unit 2**

Scalar and Vector Quantization: Scalar Quantization – Introduction, Uniform and Adaptive quantization. Vector Quantization- Introduction, Advantages, LBG, Tree vector quantization, Trellis coded quantization
Audio Compression: Distortion criteria- Auditory perception, PCM, DPCM, ADPCM, Predictive coding- basic algorithm, Basic sub-band coding, MPEG Audio Coding

**Unit 3**

Image Compression: Distortion criteria- The human visual system, Transform coding- DCT, JPEG, JBIG II, GIF, Wavelet based compression- wavelets, the scaling function, Haar Transforms, JPEG-2000. Video Compression: Motion Estimation and Compensation- Full search and Fast search algorithms, H.261, MPEG-1, MPEG-2, MPEG-4, MPEG -7.

**TEXTBOOKS:**

1. Sayood and Khalid, "Introduction to Data Compression", Third Edition, Morgan Kaufmann, 2006.

**REFERENCES:**

1. Richardson I E G, "Video Codec Design: Developing Image and Video Compression Techniques", John Wiley & Sons, 2002.
2. Salomon D, "Data Compression: The Complete Reference", Fourth Edition, Springer, 2007.
3. Gersho A and Kluwer R M G, "Vector Quantization and Signal Compression", Academic Press, 1992.

**18CSC453 Big Data Storage and Analysis 3 0 0 3**

**Unit 1**

Introduction: Scaling with Traditional Databases - NoSQL need - First Princples – Desired Properties- Lambda Architectures. Batch Layer- Big data model – properties – fact based modeling – graph schemas – Apache Thrift,

**Unit 2**

Data Storage on Batch Layers – Requirements- Solutions- Distributed File Systems and Partitioning- Hadoop basics, Computing on Batch Layer- Algorithms-Scalability-MapReduce, Batch Layer Architecture and Algorithms – Design Overview and Workflow, Ingesting New Data, Normalization.

**Unit 3**

Serving Layer- Performance Metrics, Requirements and Design, ElephantDB. Speed Layer- Realtime Views, Cassandra basics, Query and Stream Processing , Apache Storm

**TEXT BOOKS:**

1. Nathan Marz, James Warren, “Big Data: Principles and best practices of scalable real-time data systems”, Manning Publications 2015.

**REFERENCES:**

1. Tom White, “Hadoop – The Definitive Guide”, O′Reilly; 3 edition (12 June 2012)

Randy Abernethy, “Programmer's Guide to Apache Thrift”, Manning Publications, 2019

https://thrift.apache.org/

2. Jeff Carpenter, Eben Hewitt, “Cassandra: The Definitive Guide: Distributed Data at Web Scale”, 2nd Edition, O'Reilly, 2016

3. Ankit Jain, “Mastering Apache Storm”, Packt Publishing, 2017

https://www.elephantsql.com/

**18CSC449 IoT Workshop 3 0 0 3**

**Unit - 1**

Introduction to loT - loT definition - Characteristics - Things in loT - loT Complete Architectural Stack - loT enabling Technologies - loT Challenges - loT Levels - A Case Study to realise the stack.

Sensors and Hardware for loT - Accelerometer, Proximity Sensor, lR sensor, Gas Sensor,Temperature Sensor, Chemical Sensor, Motion Detection Sensor.Hardware Kits - Arduino,Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors (Lab Component)

**Unit - 2**

Protocols for loT - infrastructure protocol IPV4/V6|RPL), Identification (URLs), Transport (Wi-Fi, Li-Fi, BLE), Discovery, Data Protocols, Device Management Protocols. - A Case Study with MQTT/CoAP usage. (Lab Component)

Cloud and Data analytics- Types of Cloud - loT with cloud challenges - Selection of cloud for IoT applications - Fog computing for loT - Edge computing for loT - Cloud security aspects for loT applications - RFM for Data Analytics - Case study with AWS / AZURE / Adafruit / IBM Bluemix (Lab Component).

**Unit - 3**

Case studies with architectural analysis:

loT applications - Smart City - Smart Water - Smart Agriculture - Smart Energy - Smart Healthcare - Smart Transportation - Smart Retail -Smart waste management . (Lab Component - As a project)

**Text and Reference Books**

1. "lnternet of Things: A Hands-on Approach", by ArshdeepBahga and Vijay Madisetti (UniversitiesPress)

2. lnfosys Training E Materials.
3. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases',, by pethuru Rajand Anupama C. Raman (CRC press)
4. Adrian McEwen, Designing the internet of Things, Wiley (B November 2Ot3), ISBN-13:978-.11-L1,8430620,
5. NPTEL Reference :https://onlinecourses.nptel.ac.in/noc17_cs22/preview

**18CSC450 Introduction to Embedded Systems 3 0 0 3**

**Unit 1**

Architecture of Microprocessors: General definitions of computers, micro-processors, micro controllers and digital signal processors.

Overview of Microcontrollers- Introduction to 8051 microcontroller, General Architecture of a MCU and more specific to 8051 family MCUs, Pin diagram of 8051 MCU and various control signals, Various addressing modes of 8051, 8051 Instruction Set and Programming -Data Movement, Arithmetic & Logical, Control instructions with example programs, 8051 Interfacing with peripherals - Simple IO devices and sensor devices interfacing with 8051 MCU, Timer / counter modules and interrupts in 8051, RS232 based serial Communication using 8051

**Unit 2**

ARM Architecture: RISC Machine, Architectural Inheritance, Programmers model. ARM Organization and Implementation. 3 Stage pipeline, 5 Stage pipeline, ARM Instruction execution,ARM Implementation, Co-processor interface, ARM Assembly language Programming, Data processing instructions, Data Transfer Instructions, Control flow instructions, Architectural support for high level programming, Thumb Instruction set.

**Unit 3**

Interrupt structure of 8086 and ARM: Vector interrupt table, Interrupt service routines. Introduction to DOS and BIOS Interrupts for 8086. Asynchronous and Synchronous data transfer schemes, ARM memory interface, AMBA interface, A/D Converters, PWM, timer / counter, UART and its interfacing – Application development using Keil IDE.

**Text Book:**

1.Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay - 8051 Microcontroller and Embedded Systems, The, 2nd Edition - 2006 - pearson

1. Steve Furber “ARM System on chip Architecture” , Second edition, Addidon Wesley, 2000

**References:**

1) Douglas Hall, Microprocessors and its Interfacing (SIE), McGraw Hill Education (India), 3rd Ed., 2012.

2) Kenneth Ayala - The 8051 Microcontroller & Embedded Systems Using Assembly and C 1st Edition
3) Arnold S. Berger, “Embedded System Design”, CMP Books, USA 2002.
4) Michael Barr, “Programming Embedded Systems with C and GNU‖, O Reilly, 2003.

**18CSC451 INFORMATION RETRIEVAL 3 0 0 3**

Unit 1

Boolean Retrieval – The term vocabulary and postings lists – Dictionaries and tolerant retrieval – Index construction – Index compression – Scoring, term weighting and the vector space model – Evaluation in Information retrieval.

Unit 2

Relevance feedback and query expansion – XML retrieval – Probabilistic information retrieval – Text classification – Vector space classification – Clustering – Matrix decomposition and latent semantic indexing.

Unit 3

Web search basics – Web crawling and indexes – Link analysis.

TEXTBOOK:

Manning C D., Raghavan P a ndSchutze H., “Introduction to Information Retrieval”, Cambridge University Press, 2008

REFERENCES:

1. R.Baeza-Yates and B. RibeiroNeto, “Modern Information Retrieval: The Concepts and Technology behind Search”, Second Edition, Addison Wesley, 2011
2. David A.Grossman and OphirFrieder,”Information Retrieval: Algorithms and Heuristics”, Second Edition, Springer 2004.

**18CSC452 Social Network Analytics 3 0 0 3**

**Unit 1 :** Online Social Networks (OSNs)

Introduction - Types of social networks (e.g., Twitter, Facebook), Measurement and Collection of Social Network Data. Techniques to study different aspects of OSNs -- Follower-followee dynamics, link farming, spam detection, hashtag popularity and prediction, linguistic styles of tweets. Case Study: An Analysis of Demographic and Behaviour Trends using Social Media: Facebook, Twitter and Instagram

**Unit 2:** Fundamentals of Social Data Analytics

Introduction - Working with Social Media Data, Topic Models, Modelling social interactions on the Web – Agent Based Simulations, Random Walks and variants, Case Study: Social Network

Influence on Mode Choice and Carpooling during Special Events: The Case of Purdue Game Day

**Unit 3 :** Applied Social Data Analytics

Application of Topic models, Information Diffusion, Opinions and Sentiments - Mining, Analysis and Summarization, Case Study: Sentiment Analysis on a set of Movie Reviews using Deep Learning techniques, Recommendation Systems, Language dynamics and influence in online communities, Community identification, link prediction and topical search in social networks, Case Study: The Interplay of Identity and Social Network: A Methodological and Empirical Study

Text and Reference Literature


1. Cioffi-Revilla, Claudio. *Introduction to Computational Social Science*, Springer, 2014.
2. Matthew A. Russell. *Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More*, 2nd Edition, O'Reilly Media, 2013.
3. Robert Hanneman and Mark Riddle. *Introduction to social network methods.* Online Text Book, 2005.
4. Jennifer Golbeck, *Analyzing the social web*, Morgan Kaufmann, 2013.
5. Claudio Castellano, Santo Fortunato, and Vittorio Loreto, *Statistical physics of social dynamics*, Rev. Mod. Phys. 81, 591, 11 May 2009.
6. S. Fortunato and C. Castellano, *Word of mouth and universal voting behaviour in proportional elections*, Phys. Rev. Lett. 99, (2007).
7. Douglas D. Heckathorn, *The Dynamics and Dilemmas of Collective Action*, American Sociological Review (1996).
8. Michael W. Macy and Robert Willer, *From factors to actors: Computational Sociology and Agent-Based Modeling*, Annual Review of Sociology Vol. 28: 143-166 (2002).
9. Nilanjan Dey Samarjeet Borah Rosalina Babo Amira Ashour, *Social Network Analytics - Computational Research Methods and Techniques, First Edition*, eBook ISBN: 9780128156414, Paperback ISBN: 9780128154588, Imprint: Academic Press, Published Date: 23rd November 2018


**18CSC454 Probabilistic Graphical Models 3 0 0 3**

The aim of this course is to develop the knowledge and skills necessary to effectively design, implement and apply these models to solve real problems. The course will cover (a) Bayesian and Markov (MRF) networks; (b) exact and approximate inference methods; (c) estimation of both the parameters and structure of graphical models.

Text Book: 1. Daphne Koller and Nir Friedman, *Probabilistic Graphical Models: Principles and Techniques* MIT Press, 2018.

Reference Book:

1. Martin J. Wainwright and Michael I. Jordan, *Graphical models, exponential families, and variational inference*, 2018.
2. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective, 2018*.

19CSE Computer Networks 3 0 0 3

**FUNDAMENTALS & LINK LAYER :** Building a network – Requirements – Layering and protocols – Internet Architecture – Network software – Performance ; Link layer Services – Framing – Error Detection – Flow control.

**MEDIA ACCESS & INTERNETWORKING.** Media access control – Ethernet (802.3) – Wireless LANs – 802.11 – Bluetooth – Switching and bridging – Basic Internetworking (IP, CIDR, ARP, DHCP, ICMP )

**ROUTING:** Routing (RIP, OSPF, metrics) – Switch basics – Global Internet (Areas, BGP, IPv6), Multicast – addresses – multicast routing (DVMRP, PIM)

**TRANSPORT LAYER:** Overview of Transport layer – UDP – Reliable byte stream (TCP) – Connection management – Flow control – Retransmission – TCP Congestion control – Congestion avoidance (DECbit, RED) – QoS – Application requirements.

**APPLICATION LAYER:**Traditional applications -Electronic Mail (SMTP, POP3, IMAP, MIME) – HTTP – Web Services – DNS – SNMP .

**TEXT BOOK:**

1. Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth Edition, Morgan Kaufmann Publishers, 2011.

**REFERENCES:**

1. James F. Kurose, Keith W. Ross, “Computer Networking – A Top-Down Approach Featuring the Internet”, Fifth Edition, Pearson Education, 2009.

2. Nader. F. Mir, “Computer and Communication Networks”, Pearson Prentice Hall Publishers, 2010.

3. Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, “Computer Networks: An Open Source Approach”,Mc Graw Hill Publisher, 2011.

**18MAT446 COMPUTATIONAL GEOMETRY 3 0 0 3**

Convex hulls: construction in 2d and 3d, lower bounds; Triangulations: polygon triangulations, representations, point-set triangulations, planar graphs; Voronoi diagrams: construction and applications, variants; Delaunay triangulations: divide-and-conquer, flip and incremental algorithms, duality of Voronoi diagrams, min-max angle properties; Geometric searching: point location, fractional cascading, linear programming with prune and search, finger trees,

concatenable queues, segment trees, interval trees; Visibility: algorithms for weak and strong visibility, visibility with reflections, art-gallery problems; Arrangements of lines: arrangements of hyperplanes, zone theorems, many-faces complexity and algorithms; Combinatorial geometry: Ham-sandwich cuts, Helly's theorems, k-sets, polytopes and hierarchies, polytopes and linear programming in d-dimensions, complexity of the union of convex sets, simply connected sets and visible regions; Sweep techniques: plane sweep for segment intersections, Fortune's sweep for Voronoi diagrams, topological sweep for line arrangements; Randomization in computational geometry: algorithms, techniques for counting; Robust geometric computing; Applications of computational geometry.

References


1. Mark de Berg, Otfried Schwarzkopf, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer.
2. F. P. Preparata and Michael I. Shamos, Computational Geometry: An Introduction, Springer.
3. Joseph O' Rourke, Computational Geometry in C, Cambridge University Press.
4. Lecture Notes by David Mount.


**18MAT 441 Advanced Algebra 3 0 0 3**

Maximal Ideals, the Field of Quotients of an Integral Domain, Euclidean Rings, Principal Ideal, Unit Element, Greatest Common Divisor, Prime Elements, Unique Factorization Theorem. (Sec. 3.5 to 3.7)

The ring of Gaussian integers, Fermat's Theorem, Polynomial Rings – F[x], Degree of a Polynomial, The Division Algorithm, Principal Ideal Ring, Irreducible Polynomial a principal ideal ring, Irreducible polynomial. (Sec. 3.8 to 3.9)

Sub Fields, Field Extensions, Finite Extensions, Algebraic Extensions and Their Properties. The Transcendence of 'e'. (Sec. 5.1 to 5.2)

Roots of Polynomials, Remainder Theorem, Splitting Field and its Uniqueness, The concept of constructible numbers and its Applications, Distinct and Multiple Roots, Simple Extension of a Field. (Sec. 5.3, 5.4, 5.5).

TEXTBOOK:


1. I.N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.


REFERENCES:


1. John B. Fraleigh, 'A First Course in Abstract Algebra', Narosa Publishing House, 2003.
2. Joseph A. Gallian, 'Contemporary Abstract Algebra', Cengage Learning., 2013.
3. Howard Anton and Chris Rorres,'Elementary Linear Algebra', 9th Edition, Wiley, 2005.

Note: The Problems are to be referred from Reference Book 1.

**18MAT443 DIFFERENTIAL EQUATIONS 3 1 0 4**

**Unit 1**

Review of differential equations (order, degree, linear, nonlinear, implicit and explicit form of solution, general solutions, particular solution, singular solution). Exactness, nonexact equations reduce to exact form.

Part I: 1.1-1.9, 2.12-2.22 (5 hours)

Equations solvable for $\frac{dy}{dx}$, y, x, equations in Clairaut's form, equations reducible to Clairaut's form.

Part I: 4.1-4.11 (4 hours)

**Unit 2**

Linear homogeneous differential equations with constant coefficients, Euler- Cauchy equation, Linear Nonhomogeneous Differential Equations: Wronskian, linear independence, Method of undetermined coefficients. Method of variation of parameters.

Part I: 5.1-5.5, 6.1-6.3, 1.12,1.13, 5.26-5.27, 7.1-7.5 (9 hours)

**Unit 3**

Conversion of nth order differential equation to n first order differential equations, homogeneous linear system with constant coefficients, fundamental matrices, complex eigen values, repeated eigenvalues. simultaneous linear differential equations with constant coefficients, simultaneous linear differential equations with variable coefficients,

PART I: 8.1-8.3, 2.1- 2.7(8 hours)

Review of partial differential equations (order, degree, linear, nonlinear).

**Unit 4**

Formation of equations by eliminating arbitrary constants and arbitrary functions.

General, particular and complete integrals. Lagrange's linear equation, Charpit's method, Methods to solve the first order partial differential equations of the forms f(p,q) = 0, f(z,p,q) = 0, $f_1(x,p) = f_2(y,q)$ and Clairut's form z = px + qy + f(p,q) where $p = \frac{\partial z}{\partial x}$ and $q = \frac{\partial z}{\partial y}$.

Part III: 1.1 – 1.5, 2.3-2.12, 3.1-3.2, 3.7-3.8, 3.10-3.18 (13 hours)

**Unit 5**

Homogeneous linear partial differential equations with constant coefficient of higher order. Non-homogeneous linear partial differential equations of higher order, method of separation of variables.

Part III: 4.1-4.12 (13 hours)

**TEXTBOOKS:**

1. M.D. Raisinghania, Ordinary and Partial Differential Equations, S.Chand, 18th edition, 2016.

References:


1. William E. Boyce and Richard C.DiPrima, Elementary differential equations and boundary value problems, Wiley india, 9th edition, 2012.
2. Nita H, Shah, Ordinary and Partial Differential Equations : Theory and Applications, PHI learning, 2nd edition, 2015.
3. Dennis Zill, A First Course in Differential Equations, Cengage Learning, 9th edition, 2009.


**18MAT448 Theory of Sampling and Design of Experiments for Data Science 3-0-0-3**

**Unit I**

Simple random sampling, Stratified random sampling, systematic random sampling - estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation - Comparison of systematic sampling - Simple random sampling and stratified random sampling for a population with a linear trend.

**Unit II**

Cluster sampling – bootstrap sampling – jack knife sampling – bias and variance of estimates - Acceptance sampling for attributes, single sampling, double sampling, measuring performance of the sampling plans- OC, AOQ, ASN, ATI curves.

**Unit III**

Planning of experiments, Basic principles of experimental design, uniformity trails, analysis of variance, one-way, two-way and three-way classification models.

**Unit IV**

Completely randomized design (CRD), randomized block design (RBD) Latin square design (LSD) and Graeco-Latin square designs,

**Unit V**

Factorial experiments, $2^n$ and $3^n$ factorial experiments, analysis of $2^2$, $2^3$ and $3^2$ factorial experiments, Yates procedure, confounding in factorial experiments, fractional factorial design.

References:


1. *Cochran, W.C. Sampling Techniques, Third Edition, Wiley Eastern, (1977).*
2. *Murthy, M.N., Sampling Theory, Tata McGraw Hill, New Delhi, (1967).*
3. *Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.*
4. *Philip J. Ross, Taguchi's Techniques for quality Engineering, MaGraw-Hill , 1989.*
5. *Schilling E. G. (1982) Acceptance Sampling in Quality Control, Marcel Decker.*

**18MAT452 Statistical Quality Control 3-0-0-3**

Unit I

Introduction to Total Quality Management – Japanese System of Total Quality Management - Quality Circles - 7 Quality Control tools - 7 New Quality Control tools.

Unit –II

Basic concept of quality control, process control and product control -Process and measurement system capability analysis - Area properties of Normal distribution. Statistical process control, theory of control charts, Shewhart control charts for variables-$\bar{x}$, R, s charts, attribute control charts - p, np, c, u charts, modified control charts.

Unit III

ARL curves of control charts, moving average control charts, EWMA charts, CUSUM charts – two sided and one sided procedures – V – mask technique, process capability analysis, process capability indices, Metrics of Six sigma, The DMAIC cycle - Design for Six Sigma - Lean Sigma – Statistical tools for Six Sigma.

Unit IV

Acceptance sampling for attributes, single sampling, double sampling, multiple sampling and sequential sampling plans, rectifying inspection plans, measuring performance of the sampling plans- OC, AOQ, ASN, ATI curves.

Unit V

Taguchi methods: Meaning of Quality, Taguchi's loss function, Introduction to orthogonal arrays – test strategies, steps in designing, conducting and analyzing an experiment, parameter and tolerance design: control and noise factors, signal to noise ratios, experimental design in Taguchi Methods, orthogonal arrays and parameter Design.

***TEXT AND REFERENCE BOOKS***


1. *Ishikawa K., Guide to Quality Control, 2nd Edition: Asian Productivity Organization, Tokyo (1983).*
2. *Ravichandran. J, Probability and Statistics for Engineers, 1st Edition 2012 (Reprint), Wiley India.*
3. *Montgomery Douglas C., Introduction to Statistical Quality Control, Sixth Edition. John Wiley & Sons, (2008).*
4. *Harry, M and Schroeder R., Six Sigma: The Breakthrough Management Strategy. Currency Publishers, USA. (2000).*
5. *Taguchi G, Introduction to Quality Engineering: Designing Quality into Products and Processes, Asian Productivity Organization, Second Edition. (1991).*


**18MAT444 Multivariate Statistics and Time series 3-0-0-3**

Multivariate Data: Random Vector: Probability mass and density functions, Distribution function, Mean vector & Dispersion matrix. Multivariate and Bivariate normal distributions.

Factor Analysis: The orthogonal factor model, methods of estimating factor loadings - the principal component method, principal factor method, maximum likelihood estimation. Factor rotation: orthogonal factor rotation, varimax rotation, quartimax rotation, oblique rotation.

Multiple correlation, partial correlation, hypothesis tests for multiple and partial correlations and canonical correlation

Time series as a discrete parameter stochastic process, Auto - covariance, Auto-correlation functions and their properties, moving average models , autoregressive models, Autoregressive Moving Average models.

**Text Books:**


1. Johnson, R and Wichern(1992): Applied Multivariate Statistical Analysis, Prentice Hall, India, 6thedition.
2. Anderson, T.W. The Statistical Analysis of Time Series, John Wiley, New York, 1971.


**References:**


1. Anderson, T. W. (1983): An Introduction to Multivariate Statistical Analysis. 3rdEd. Wiley.
2. Box, G.E.P. and Jenkins, G.M. Time Series Analysis- Forecasting and Control, Holden-day, San Francisco,1976.


**18MAT445** **WAVELETS** **3 0 0 3**

**Unit-I** Basic Properties of the Discrete Fourier Transform, Translation-Invariant Linear Transformations. The Fast Fourier Transform.

**Unit-II** Construction of Wavelets on $Z_N$, The First Stage Construction of Wavelets on $Z_N$, The Iteration Step. Examples and Applications, $l_2(Z)$.

**Unit-III** Complete Orthonormal Sets in Hilbert Spaces, $L_2([-\pi,\pi))$ and Fourier Series, The Fourier Transform and Convolution on $l_2(Z)$, First-Stage Wavelets on $Z$

**Unit-IV** The Iteration Step for Wavelets on Z, Implementation and Examples.

**Unit-V** $L_2(R)$ and Approximate Identities, The Fourier Transform on $R$, Multiresolution Analysis and Wavelets, Construction of Multiresolution Analyses, Wavelets with Compact Support and Their Computation.

**References:**


1. Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer,1999.
2. Daubechis, Ten Lectures on Wavelets, SIAM, 1992.
3. Mallat, S. A Wavelet Tour of Signal Processing, Elsevier, 2008.


**18MAT447 QUEUING THEORY AND INVENTORY CONTROL 3-0-0-3**

**Unit I**

Inventory concept – Components of Inventory model.

**Unit II**

Deterministic Continuous Review model - Deterministic Periodic Review model.

**Unit III**

The classical EOQ – Non zero lead time – EOQ with and without shortages.

**Unit IV**

Deterministic Multiechelon Inventory models for supply chain management.

Unit V

A stochastic continuous review model – A stochastic single period model for perishable products.

**TEXT BOOKS**


1. F S Hillier and Gerald J Lieberman, Introduction to Operations research, 8th edition, McGraw Hill.
2. Ravindran , Phillips and Solberg, Operations research Principles and Practice, 2nd Edition, John Wiley & Sons.


**18MAT453 SIX SIGMA QUALITY ANALYSIS 3 0 0 3**

Unit 1

Introduction to Quality Management – Japanese System of Total Quality Management.

Unit 2
Quality Circles - 7 Quality Control tools - 7 New Quality Control tools.

Unit 3
ISO 9000 Quality system Standards - Project Planning, Process and measurement system capability analysis - Area properties of Normal distribution.

Unit 4
Metrics of Six sigma, The DMAIC cycle - Design for Six Sigma - Lean Sigma – Statistical tools for Six Sigma.

Unit 5
Taguchi methods. Loss functions and orthogonal arrays and experiments.

*TEXT AND REFERENCE BOOKS*


6. *Ravichandran. J, Probability and Statistics for Engineers, 1st Edition 2012 (Reprint), Wiley India.*
7. *Montgomery Douglas C., Introduction to Statistical Quality Control, Sixth Edition. John Wiley & Sons, (2008).*
8. *Ishikawa K., Guide to Quality Control, 2nd Edition: Asian Productivity Organization, Tokyo (1983).*
9. *Taguchi G, Introduction to Quality Engineering: Designing Quality into Products and Processes Second Edition. (1991).*
10. *Harry, M and Schroeder R., Six Sigma: The Breakthrough Management Strategy. Currency Publishers, USA. (2000).*


**18MAT450 Data Analytics in Computational Biology 3 0 0 3**

Introduction to Bioinformatics - applications of Bioinformatics - challenges and opportunities - introduction to NCBI data model- Various file formats for biological sequences.

Bioinformatics resources – Importance of databases - Biological databases- Primary & Secondary databases (Genbank, EMBL, DDBJ, Swiss Prot , PDB, NDB, BLOCKS, Pfam, ProSITE, etc.).

Sequence alignment methods: Sequence analysis of biological data-Significance of sequence alignment- pairwise sequence alignment methods- Use of scoring matrices and gap penalties in sequence alignments- PAM and BLOSUM Scoring Matrices. Introduction to Dynamic

Programming, Global alignments: Needleman Wunsch Algorithm, Local Alignments: Smith Waterman Algorithm, Gap Penalties.

Multiple sequence alignment methods – Tools and application of multiple sequence alignment. Sequence alignment tools (BLAST, FASTA, CLUSTAL-W/X, MUSCLE, TCOFFEE), Variants of BLAST (BLASTn, BLASTp, PSIBLAST, PHI-BLA

Phylogenetic analysis algorithms: Maximum Parsimony, UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining, jackknife, Probabilistic models and associated algorithms such as Probabilistic models of evolution and maximum likelihood algorithm, Bootstrapping methods, use of tools such as PHYLIP, MEGA, PAUP.

**References/ Textbooks**

1 Higgins,Des and Taylor Williw: Bioinformatics: Sequence , Structure and databanks, Oxford , University Press,2000.
2. Baxenvants, AD., Bioinformatics: A practical guide to the analysis of genes and proteins", Third edition, John wiley &
Sons ,2005
3. Teresa Attwood, Introduction To Bioinformatics ,Pearson Education Singapore Pte Ltd, 2007
4. Mount, DW, Bioinformatics: Sequence and Genome analysis", Second edition, Cold Spring Harbor Laboratory Press. Baxevanis 5. A.D., Davison D.B., Page R. D. M. & Petsko G.A. Current Protocols in Bioinformatics. New York, John Wiley &
Sons Inc., 2004. ISBN: 0555015254
6. S.C. Rastogi et al, Bioinformatics: Methods and Applications: (Genomics, Proteomics and Drug Discovery) Kindle Edition.

**18MAT451 Computer Aided Drug Designing 3 0 0 3**

Introduction to Molecular Modeling: Molecular Modeling and Pharmacoinformatics in Drug Design, Phases of Drug Discovery, Target identification and validation

Protein Structure Prediction and Analysis: Protein Structure prediction methods: Secondary Structure Prediction, Tools for Structure prediction; Protein structural visualization; Structure validation tools; Ramachandran Plot.

QSAR : Quantitative Structure and Activity Relationship - Historical Development of QSAR, Tools and Techniques of QSAR, Molecular Structure Descriptors.

Multivariate Statistical methods in QSAR -Principal Component Analysis (PCA) and Hierarchical Cluster Analysis(HCR). Regression analysis tools - Pincipal Component Regression (PCR), Partial Least Squares (PLS) - Case studies.

High Throughput / Virtual screening- Introduction, Basic Steps, Important Drug Databases, Designing Lipinski's Rule of Five, ADMET screening

Docking Studies- Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking .

Molecular visualization tools: RasMol and Swiss-Pdb Viewer

Molecular docking tools: AutoDock and ArgusLab.

**References/ Textbooks**


1. Leach Andrew R., Valerie J. Gillet, An introduction to Chemoinformatics. Publisher: Kluwer academic , 2003. ISBN: 1402013477.
2. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes), 2003. Publisher: Wiley-VCH. ISBN:3527306803.
3. Opera Tudor I,Ed. , Chemoinformatics in drug discovery, Wiley-VCH Verlag,2005.
4. Bunin Barry A. Siesel Brian,Morales Guillermo,Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006. ISBN: 1402050003.
5. Gasteiger Johann, Engel Thomas. Chemoinformatics: A Textbook. Publisher: WileyVCH; 1st edition. 2003. ISBN: 3527306811.
6. Kenneth M Merz, Jr, Dagmar Ringe, Charles H. Reynolds , Drug design: Structure and ligand based approaches (2010) publisher : Cmabridge University press


**18MAT442 ADVANCED BIG DATA ANALYTICS 3-0-0-3**

Unit - I

How MapReduce Works - Anatomy of a MapReduce Job Run, Failures, Shuffle and Sort, Task Execution

Unit -II

MapReduce Types and Formats - MapReduce Types, Input Formats, output formats,

Unit- III

MapReduce Features- Counters, Sorting, Joins, Side Data Distribution

Unit -IV

Simple analytics using MapReduce, Calculating frequency distributions and sorting using MapReduce, Calculating histograms using MapReduce, Calculating scatter plots using MapReduce

Unit – V

Hierarchical clustering, Clustering algorithm to large dataset, classification using Navie bayes classifier, other applications

Text Books/References:

1. Tom White , Hadoop: The Definitive Guide, Fourth Edition , O'Reilly Media ,2009
2. Srinath Perera and Thilina Gunarathne , Hadoop MapReduce Cookbook : Recipes for analyzing large and complex datasets with Hadoop MapReduce, Packt PublishingLtd,2013.

**18MAT454 Statistical Pattern Recognition 3-0-2-4**

***UNIT I***

Introduction and Bayesian Decision Theory– Pattern recognition systems – the design cycle – learning and adaptation – Bayesian decision theory – continuous features – Minimum error rate classification – discriminant functions and decision surfaces – the normal density based discriminant functions.

UNIT II

Maximum likelihood estimation – Bayesian estimation - Bayesian parameter estimation – Gaussian case and general theory – problems of dimensionality – components analysis and discriminants – hidden Markov models.

UNIT III

Nonparametric techniques and linear discriminant functions- density estimation – Parzen windows – nearest neighbourhood estimation – rules and metrics – linear discriminant functions and decision surfaces – generalized linear discriminant functions – two-category linearly separable case – minimizing the perception criterion function.

UNIT IV

Nonmetric methods and algorithm-independent machine learning- decision trees – CART methods – algorithm-independent machine learning – lack of inherent superiority of any classifier – bias and variance for regression and classification – resampling or estimating statistics – estimating and comparing classifiers.

UNIT V

Unsupervised learning and clustering – mixture densities and identifiability – maximum likelihood estimates – application to normal mixtures – unsupervised Bayesian learning – data description and clustering – criterion functions for clustering – hierarchical clustering – component analysis – low-dimensional representations and multi-dimensional scaling.

*References:*

1. *Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Classification", Second Edition, 2003, John wily & sons.*
2. *Earl Gose, Richard Johnsonbaugh and Steve Jost, "Pattern Recognition and Image Analysis, 2002, Prentice Hall of India.*
3. *Nilsson N J, "The Quest for Artificial Intelligence", Cambridge University Press, 2009.*