5-yr Integrated M Sc –Data Science

CURRICULUM AND SYLLABUS

(From 2022 Admission Onwards)
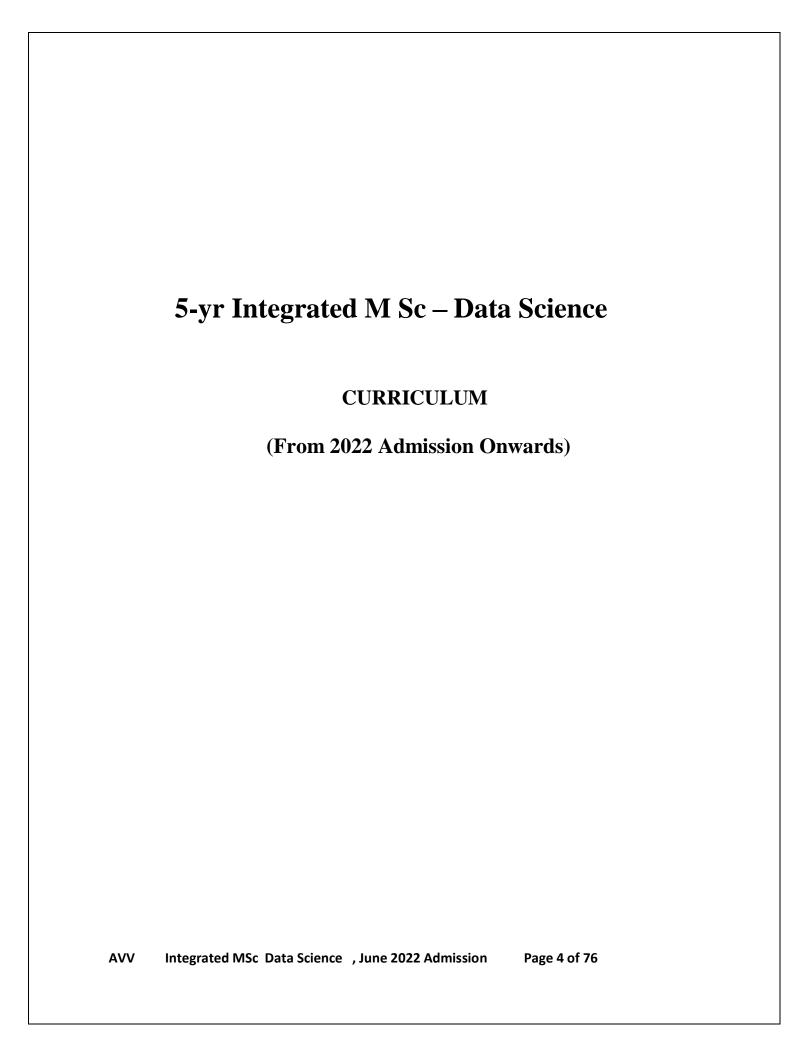
Vision of the Institute

To be a global leader in the delivery of engineering education, transforming individuals to become creative, innovative, and socially responsible contributors in their professions.

Mission of the Institute:

∗ To provide best-in-class infrastructure and resources to achieve excellence in technical education,

∗ To promote knowledge development in thematic research areas that have a positive impact on society, both nationally and globally,

∗ To design and maintain the highest quality education through active engagement with all stakeholders –students, faculty, industry, alumni and reputed academic institutions,

∗ To contribute to the quality enhancement of the local and global education ecosystem,

∗ To promote a culture of collaboration that allows creativity, innovation, and entrepreneurship to flourish, and

∗ To practice and promote high standards of professional ethics, transparency, and accountability.

PROGRAM OUTCOMES (PO)

PO1 **Knowledge in Mathematical Science**: Understand the basic concepts, fundamental principles and the scientific theories related to mathematical sciences.

PO2 **Abstract thinking**: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematical sciences.

PO3 **Modelling and solving**: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO4 **Advanced theories and methods**: Understand advanced theories and methods to design solutions for complex mathematical problems

PO5 **Applications in Engineering and Sciences**: Understand the role of mathematical sciences and apply the same to solve the real life problems in various fields of study.

PO6 **Modern software tool usage:** Acquire the skills in handling scientific tools towards solving problems and solution analysis.

PO7 **Environment and sustainability**: Understand the significance of preserving the environment towards sustainable development.

PO8 **Ethics**: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Continue to enhance the knowledge and skills in mathematical sciences for constructive activities and demonstrate highest standards of professional ethics.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO10 **Communication:** Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.

PO11 **Project management and Research**: Demonstrate knowledge, understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in mathematical sciences.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

5-yr Integrated M Sc – Data Science

CURRICULUM

(From 2022 Admission Onwards)

Course Code	Course Title	L T P	Cr		Course Code	Course Title	L T P	Cr
	SEMESTER 1					**SEMESTER 2**		
21ENG101	Communicative English	2 0 2	3		21ENG111	Professional Communication	1 0 2	2
	Language Paper I	1 0 2	2			Language Paper II	1 0 2	2
22MAT108	Calculus	3 1 0	4		22MAT118	Vector Calculus	3 1 0	4
22MAT109	Linear Algebra	3 0 2	4		22MAT119	Discrete Mathematics	3 0 2	4
22PHY101	Physics	3 0 0	3		22CSC111	Advanced Computer Programming	3 0 0	3
22CSC101	Problem Solving and Computer Programming	3 0 0	3		22CSC112	Digital Electronics	3 0 0	3
22CSC181	Problem solving computer Lab	0 0 2	1		22CSC182	Advanced Computer Programming Lab.	0 0 2	1
22PHY181	Physics Lab	0 0 2	1		22CSC183	Digital Electronics Lab	0 0 2	1
21CUL101	Cultural Education I	2 0 0	2		21CUL111	Cultural Education II	2 0 0	2
					22AVP103	Mastery Over Mind	1 0 2	2
	TOTAL		**23**			TOTAL		**24**
	SEMESTER 3					**SEMESTER 4**		
22CSC201	Data Structures	3 1 0	4		22MAT227	Statistical Inference Theory	3 0 0	3
22MAT224	Optimization Techniques	3 1 0	4		22MAT228	Introduction to Modern Algebra	3 0 0	3
22MAT225	Probability Theory	3 1 0	4		22MAT229	Convex Optimization	3 0 0	3
22MAT226	Numerical Methods	3 1 0	4		22CSC211	Design and Analysis of Algorithms	3 1 0	4
22CSC202	Foundations of Data Science	3 0 2	4		22CSC212	Database Management Systems	3 1 0	4
19ENV300	Environmental Science		P/F			Open Elective A*	3 0 0	3
22MAT286	Data Science Lab-I: Statistics and Numerical Methods Lab	0 0 2	1		22MAT287	Data Science Lab-II: Inference Theory	0 0 2	1
21AVP201	Amrita Values Programme I	1 0 0	1		21SSK211	Life Skills II	1 0 2	2
22CSC281	Data Structures lab	0 0 2	1		22CSC282	Design and Analysis of Algorithms Lab	0 0 2	1
21SSK201	Life Skills I	1 0 2	2		21AVP211	Amrita Values Programme II	1 0 0	1
	TOTAL		**25**			TOTAL		**25**
	SEMESTER 5					**SEMESTER 6**		
22CSC301	Operating Systems	3 0 2	4		22MAT321	Graph Analytics and Algorithms	3 0 2	4
22MAT310	Multivariate Statistics for Data Science	3 0 2	4		22MAT322	Regression Analysis	3 0 2	4
22CSC302	Number Theory and Information Security	3 1 0	4		22CSC311	Machine Learning	3 1 0	4
22CSC303	Theory of Computation	3 0 2	4		22CSC312	Data Visualization	3 0 2	4
22CSC304	Database Design	3 0 0	3		22CSC313	Computer Networks	3 0 2	4
22MAT392@	Live-in-Lab.@ / Open Elective B*	3 0 0	3		22CSC314	Data Governance, Ethics and Law	1 0 0	1
21SSK301	Life Skills III	1 0 2	2		22CSC382	Machine Learning-Lab	0 0 2	1
22CSC381	Database Management Systems Lab	0 0 2	1		22CSC383	Open Lab I (JAVA / C / C++ / R programming / Azure …)	0 0 2	1
	TOTAL		**25**			TOTAL		**23**
	SEMESTER 7					**SEMESTER 8**		
22MAT401	Probabilistic Graphical Models for Data Science	3 0 2	4		22CSC411	Software Engineering	3 0 2	4
22CSC401	Deep Learning	3 0 2	4		22CSC412	Deep Learning for Natural Language Processing	3 0 2	4
22CSC402	Practical Techniques for Big Data Analytics	3 0 2	4			Elective III	2 0 2	3
22CSC403	Reinforcement Learning	3 0 2	4			Elective IV	2 0 2	3

Code	Course	L T P	C		Code	Course	L T P	C
22CSC404	Data Security	3 0 0	3			Elective V	2 0 2	3
	Elective I	2 0 2	3		22CSC490	Mini Project		5
	Elective II	2 0 2	3		22CSC413	Internet of Things	1 0 2	2
22CSC481	Open Lab-II (Algorithms.io / Hadoop / Cascading / web design./ RapidMiner../ Research paper)	0 0 2	1		22CSC482	Open Lab-III (Apache Spark / Big ML /Apache Hive/ Research paper/…)	0 0 2	1
	TOTAL		**26**			TOTAL		**25**
	SEMESTER 9					**SEMESTER 10**		
22CSC691	Project –I(Internship in Industries / Universities)		8		22CSC699	Project-II (Research based) Dissertation		12
	Elective VI	2 0 2	3					
	Elective VII	2 0 2	3					
	Total		**14**			TOTAL		**12**
						Total Credits	**222**	
	MATHEMATICS STREAM					**COMPUTER SCIENCE STREAM**		
22MAT431	Real Analysis	2 0 2	3		22CSC541	Soft Computing	2 0 2	3
22MAT432	Advanced Algebra	2 0 2	3		22CSC542	Cryptography	2 0 2	3
22MAT433	Transform Techniques	2 0 2	3		22CSC543	Business Analytics	2 0 2	3
22MAT434	Advanced Big Data Analytics	2 0 2	3		22CSC544	Deep Learning for Image Processing	2 0 2	3
22MAT435	Differential Equations	2 0 2	3		22CSC545	Predictive Analytics	2 0 2	3
22MAT436	Random Process for Data Analytics	2 0 2	3		22CSC546	Mining of Massive Datasets	2 0 2	3
22MAT437	Time Series Analysis	2 0 2	3		22CSC547	Data Compression	2 0 2	3
22MAT438	Wavelets	2 0 2	3		22CSC548	Introduction to Embedded Systems	2 0 2	3
22MAT439	Computational Geometry	2 0 2	3		22CSC549	Information retrieval	2 0 2	3
22MAT440	Queuing Theory and Inventory Control	2 0 2	3		22CSC550	Social Network Analytics	2 0 2	3
22MAT441	Theory of Sampling and Design of Experiments for Data Analysis	2 0 2	3		22CSC551	Big Data Storage and Analysis	2 0 2	3
22MAT442	Data Analytics in Computational Biology	2 0 2	3		22CSC552	Full Stack Development	2 0 2	3
22MAT443	Computer Aided Drug Designing	2 0 2	3		22CSC553	Cloud Computing	2 0 2	3
22MAT444	Statistical Quality Control	2 0 2	3		22CSC554	Data Wrangling	2 0 2	3
22MAT445	Six Sigma Analytics	2 0 2	3		22CSC555	Parallel and Distributed Systems	2 0 2	3
22MAT446	Statistical Pattern Recognition	2 0 2	3		22CSC556	High Performance Computing	2 0 2	3
					22CSC557	Advance Deep Learning	2 0 2	3

Elective courses can be taken from online courses, industry electives and other B.Tech / M.Tech/ M. Sc programmes.
@ code for live in Lab

		LANGUAGES									
		Paper I						**Paper II**			
	21HIN101	Hindi I	1 0 2	2	B		21HIN111	Hindi II	1 0 2	2	B
	21TAM101	Tamil I	1 0 2	2	B		21TAM 111	Tamil II	1 0 2	2	B
	21KAN101	Kannada I	1 0 2	2	B		21KAN111	Kannada II	1 0 2	2	B
	21MAL101	Malayalam I	1 0 2	2	B		21MAL111	Malayalam II	1 0 2	2	B
	21SAN101	Sanskrit I	1 0 2	2	B		21SAN111	Sanskrit II	1 0 2	2	B

Open Electives UG				
Course Code	**Course Title**	**L – T – P**	**Cr.**	**ES**
21OEL231	A Journey towards Free India	3 0 0	3	J
21OEL232	Political Leadership	3 0 0	3	J
21OEL233	Social issues in Contemporary India	3 0 0	3	J
21OEL234	The Story of Indian Business	3 0 0	3	J
21OEL235	Industrial Psychology	3 0 0	3	J
21OEL236	Advertising	3 0 0	3	J
21OEL237	Basic Statistics	3 0 0	3	J
21OEL238	Citizen Journalism	3 0 0	3	J
21OEL239	Creative Writing for Beginners	3 0 0	3	J
21OEL240	Desktop Support and Services	3 0 0	3	J
21OEL241	Development Journalism	3 0 0	3	J
21OEL242	Digital Photography	3 0 0	3	J
21OEL243	Emotional Intelligence	3 0 0	3	J
21OEL244	Essence of Spiritual Literature	3 0 0	3	J
21OEL245	Film Theory	3 0 0	3	J
21OEL246	Fundamentals of Network Administration	3 0 0	3	J
21OEL247	Gender Studies	3 0 0	3	J
21OEL248	Glimpses of Indian Economy and Polity	3 0 0	3	J
21OEL249	Graphics and Web-designing Tools	3 0 0	3	J
21OEL250	Green Marketing	3 0 0	3	J
21OEL251	Healthcare and Technology	3 0 0	3	J
21OEL252	History of English Literature	3 0 0	3	J
21OEL253	Indian Writing in English	3 0 0	3	J
21OEL254	Industrial Relations and Labour Welfare	3 0 0	3	J
21OEL255	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
21OEL256	Introduction to Computer Hardware	3 0 0	3	J
21OEL257	Introduction to Event Management	3 0 0	3	J
21OEL258	Introduction to Media	3 0 0	3	J
21OEL259	Introduction to Right to Information Act	3 0 0	3	J

21OEL260	Introduction to Translation	3 0 0	3	J
21OEL261	Linguistic Abilities	3 0 0	3	J
21OEL262	Literary Criticism and Theory	3 0 0	3	J
21OEL263	Macro Economics	3 0 0	3	J
21OEL264	Managing Failure	3 0 0	3	J
21OEL265	Media Management	3 0 0	3	J
21OEL266	Micro Economics	3 0 0	3	J
21OEL267	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
21OEL268	Negotiation and Counselling	3 0 0	3	J
21OEL269	New Literatures	3 0 0	3	J
21OEL270	Non-Profit Organization	3 0 0	3	J
21OEL271	Personal Effectiveness	3 0 0	3	J
21OEL272	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
21OEL273	Principles of Marketing	3 0 0	3	J
21OEL274	Principles of Public Relations	3 0 0	3	J
21OEL275	Science, Society and Culture	3 0 0	3	J
21OEL276	Statistical Analysis	3 0 0	3	J
21OEL277	Teamwork and Collaboration	3 0 0	3	J
21OEL278	The Message of Bhagwad Gita	3 0 0	3	J
21OEL279	Understanding Travel and Tourism	3 0 0	3	J
21OEL280	Videography	3 0 0	3	J
21OEL281	Vistas of English Literature	3 0 0	3	J
21OEL282	Web-Designing Techniques	3 0 0	3	J
21OEL283	Organic Farming	3 0 0	3	J
21OEL284	Basic Legal Awareness on Protection of Women and Rights	3 0 0	3	J
21OEL285	Ritual Performances of Kerala	3 0 0	3	J
21OEL286	Documenting Social Issues	3 0 0	3	J
21OEL287	Fabrication of Advanced Solar Cell	3 0 0	3	J
21OEL288	Basic Concepts of X-ray Diffraction	3 0 0	3	J
21OEL289	Introduction to FORTRAN and GNUPLOT	3 0 0	3	J
21OEL290	Introduction to Porous Materials	3 0 0	3	J

21OEL291	Forensic Science	3 0 0	3	J
21OEL292	Introduction to solar Physics	3 0 0	3	J
21OEL293	Recycling Recovery and Treatment Methods for Wastes	3 0 0	3	J
21OEL294	Acting and Dramatic Presentation	2 0 2	3	J
21OEL295	Computerized Accounting	2 0 2	3	J
21OEL296	Kerala Mural Art and Painting	2 0 2	3	J
21OEL297	Painting	2 0 2	3	J
21OEL298	Reporting Rural Issues	3 0 0	3	J

Integrated_MSc_Maths - 2022 Onwards 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

Evaluation Pattern

50:50 (Internal: External) (All Theory Courses)

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

80:20 (Internal: External) (Lab courses and Lab based Courses having 1 Theory hour)

Assessment	Internal	External
*Continuous Assessment (CA)	80	
End Semester		20

70:30(Internal: External) (Lab based courses having 2 Theory hours/ Theory and Tutorial) Theory- 60 Marks; Lab- 40 Marks

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
Continuous Assessment (Lab) (CAL)	40	
End Semester		30

65:35 (Internal: External) (Lab based courses having 3 Theory hours/ Theory and

Tutorial) Theory- 70 Marks; Lab- 30 Marks

Marks

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA –Can be Quizzes, Assignment, Projects, and Reports.

Letter Grade	Grade Point	Grade Description
O	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail

Grades O to P indicate successful completion of the course

$$CGPA = \frac{\sum (C_i \, x \, Gr_i)}{\sum C_i}$$

Where

C_i = Credit for the ith course in any semester

Gr_i = Grade point for the ith course

Cr. = Credits for the Course

Gr. = Grade Obtained

5-yr Integrated M Sc – Data Science

SYLLABI

(From 2022 Admission Onwards)

22MAT108 **CALCULUS** **3 1 0 4**

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.

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

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

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

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.

22MAT109   **Linear Algebra**   **3 0 2 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. Sheldon Axler, Linear Algebra Done Right, Springer, 2014.
3. Gilbert Strang, "*Linear Algebra for Learning Data*", Cambridge press, 2019.
4. Kenneth Hoffmann and Ray Kunze, *Linear Algebra*, Second Edition, Prentice Hall, 1971.
5. Mike Cohen, Practical Linear Algebra for Data Science, Oreilly Publisher, 2022.

22PHY101   **Physics**   **3 0 0 3**

Objective of the course

The objective of the course is to make students understand how physics is applied to the phenomena observed in the real world. The course also aims in enhancing the problem-solving skills using techniques that require mathematical skills, conceptual and mathematical models.

At the end of the course students **will be able to**:

CO1 : understand basic physics associated with kinematics in 1,2,&3 dimensions, explain the meaning of conservation(energy& Momentum) and use it to compare the changes occurring during collision of two objects

CO2 : apply Newton's law of universal gravitation to find the gravitational force between two masses ,use Kepler's law of harmonies to make calculations regarding the radius and period of orbits of planets.

CO3 : Understand rigid bodies, draw clear and appropriate free body diagrams. determine the mass moments and products of inertia for arbitrary rigid bodies, analyse the motion of rotating systems, calculate the inertia tensor for simple objects

CO4 :. understand Variance& invariance, check invariance of different laws of Physics under Galilean transformations& explain the meaning and significance of the postulate of Special Relativity.

CO5 : understand the fundamentals of the mechanics of continuous systems, solve problems based on principle of least action and write Lagrangian for mechanical system in terms of generalised coordinates

Skills Acquired : Develops logical skills in applying and analysing problems in mechanics

Unit –I: Force, Energy, Momentum & Collisions   **(8 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- solve problems based on Newtons laws of motion.

LO2- identify types of mechanical energy possessed by an object.

LO3 -predict whether an object's total mechanical energy would be conserved or not conserved based upon the types of forces which are doing work upon the object.

LO4 - apply the principles of energy conservation to a various of physical situations.

LO5- determine the momentum of total system and to state what momentum conservation is.

LO6- apply the principle of momentum conservation to solve collision problems.

One-, two- and three-dimensional motion under forces – Energy and momentum conservation- collision in one and two dimensions.

Unit-II: Gravitation & Kepler's laws   **(10 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- calculate the gravitational force experienced by two objects.

LO2- Relate Kepler's laws to Newton's universal law of gravitation

LO3- solve problems based on the concept of gravitational potential energy

LO4- apply Kepler's law to find the characteristics of orbit

Newton's laws- Gravitation- Central force motion and application to planetary motion- Kepler's laws

Unit-III: Rotational dynamics   (10 Hr)

Learning objectives

After completing this chapter, student will be able to

LO1- construct appropriate free-body diagrams and solve problems in two-dimensional rigid-body dynamics.

LO2- Apply appropriate mathematical equations to solve problems based on torque and moment of inertia.

LO3- Understand the inertia matrix and the principal moments and principal directions at any point in a rigid body or system of particles

Rotational motion of a rigid body, Potential energy, Euler's angles-Euler's Equation-Moment of inertia tensor

Unit- IV: Special Theory of relativity   (7 Hr)

Learning objectives

After completing this chapter, student will be able to

LO1- understand the concept of constant relative motion of different bodies in different frames of references

LO2- use Lorentz transformations to apply the concepts of length contraction and time dilation

 LO3-Describe relativistic effects seen in conservation of momentum and perform calculations involving mass energy equivalence

Frames of reference, Galilean relativity, non-inertial frames, Lorentz transformation-basic special relativity- velocity addition- Relativistic momentum

Unit – V: Lagrangian formalism   (10 Hr)

Learning objectives

After completing this chapter, student will be able to

LO1- Apply variational calculus to demonstrate principle of least action

LO2- define generalised coordinates, generalised velocities, generalised force

LO3- Identify the motion of a mechanical system using Lagrange formalism

LO4- qualitatively analyze, understand the mechanical systems

Least action principle, phase space, Langarangian Formulation- Applications

Text Book

1. Principles of Physics, Walker, Halliday & Resnick, Wiley, Tenth Edition

2. Mechanics: C. Kittel, W.D. Knight, M.A. Ruderman, C.A. Helmholz and B.J. Moyer (2008) Berkeley Physics Vol 1, Tata McGraw-Hill Ltd

3. Feynman Lectures in Physics Vol:1 : Feynman, R. P., Leighton, R. B., & Sands, M. L, Pearson (2020)

Reference Books
1. Classical Mechanics: R.D. Gregory (2008) Cambridge University Press

2. Introduction to Classical Mechanics: D. Morin (2009) Cambridge University Press

3. Classical Mechanics: J.R. Taylor (2005) University Science Books

4. Mechanics: L.D. Landau and I.M. Lifshitz (2007) 3 edition, Butterworth-Heinemann

CO-PO Mapping

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**2**									
CO2	**3**	**2**	**2**									
CO3	**3**	**2**	**2**	1								
CO4	3	2	2									
CO5	3	2	3	1								

22PHY181　　　　**Physics Lab - Mechanics and Properties of Matter**　　**0 0 2 1**

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

22CSC101　　　　**Problem Solving and Computer Programming**　　　　**3 0 0　3**

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.

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.
 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.

22CSC181   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.

22MAT118   VECTOR CALCULUS   3 1 0 4

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.

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.

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.

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.

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.

| 22MAT119 | Discrete Mathematics | 3 0 2 4 |

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)

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)

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.

22CSC112   **Digital Electronics**   **3 0 0 3**

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

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.

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.

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

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.

22CSC183   **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.

22CSC111   Advanced Computer Programming   3 0 0   3

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.

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.

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.

Text Book:

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

22CSC182   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.

Text Book:

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

22MAT225   **Probability Theory**   **3 1 0 4**

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

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

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.

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.

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.

22MAT224   **Optimization Techniques**   **3 1 0 4**

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.

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

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

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

Sections 19.1 -19.6

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.

5. Bertsimas, Dimitris, and John Tsitsiklis. *Introduction to Linear Optimization*. Belmont, MA: Athena Scientific, 1997.

22MAT226   **Numerical Methods**   **3 1 0 4**

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.

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

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

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.

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

TEXT BOOKS:

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,

22CSC201   **Data Structures**   **3 1 0   4**

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.

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 .

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.

22CSC281	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.

22CSC202	FOUNDATIONS OF DATA SCIENCE	3-0-2-4

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.

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.

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.

22MAT286   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.

22MAT227   **Statistical Inference Theory**   **3-0-0-3**

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.

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.

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

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

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.

Text books:

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.

22MAT228   **Introduction to Modern Algebra**   **3 0 0 3**

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)**

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)**

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

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.

22MAT229	**CONVEX OPTIMIZATION**	3 0 0 3

Introduction: Mathematical optimization, Convex optimization, Least-squares and linear programming, simplex method, Two phase method, Integer linear programming, Nonlinear optimization.

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

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.

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

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.

22CSC211   **Design and Analysis of Algorithms**   **3 1 0 4**

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.

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.

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.

22CSC212   Database Management Systems   3 1 0 4

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.

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.

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.

22CSC282   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.

22MAT287　　　　　**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

22CSC301　　　　　**OPERATING SYSTEMS**　　　　　**3 0 2 4**

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.

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.

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.

TEXT BOOK:

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.

22MAT310   Multivariate Statistics for Data Science   3 0 2 4

The Organization of Data, Two-Dimensional Scatter Plots, Distance, Random Vectors and Matrices, Mean Vectors and Covariance Matrices, Geometry of the Sample, Random Samples, The Expected values of the Sample Mean and Covariance Matrix, The Multivariate Normal Density and its Properties, The Sampling Distribution of sample mean (X bar) and S, Large Sample behaviour of X bar and S. Principal component analysis, discriminant analysis and Factor analysis - Separation and Classification of Two Populations, Classification with Two Multivariate Normal Populations, Classification with Several Populations.

Text Books:
1. Johnson, R.A., and Wichern, D.W. (2007). *Applied Multivariate Statistical Analysis.* 6th Edition, Prentice Hall, New York.
2. T. W. Anderson (2003), *An Introduction to Multivariate Statistical Analysis*, 3rd Edition, John Wiley and Sons, New Jersey, USA.

Book for Reference:
1. Morrison(1990). Multivariate Statistical Methods, McGraw-Hill,
2. *Hair, Joseph F.; Black, William C.; Babin, Barry J.; Anderson, Rolph E.* Multivariate data analysis, 7th edition, Pearson.

22CSC302   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.

22CSC303   **THEORY OF COMPUTATION**   **3 0 2 4**

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

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

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, the Church Turing thesis, decidability, halting problems, - PCP Computation histories – Reducibility.

TEXTBOOK:

1. *Michael Sipzer, "Introduction to the Theory of Computation", Third Edition, Cengage Learning, 2012.*

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

22CSC304	Database Design	3-0-0-3

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

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

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 BOOK:

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.

22CSC381   **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.

22MAT321   **Graph Analytics and Algorithms**   **3 0 2 4**

Review of Graphs: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm. Eccentricity.
Trees: Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees, DFS, BFS algorithms.

Connectivity: Graph connectivity, k-connected graphs and blocks.
Euler and Hamilton Graphs: Euler graphs, Euler's theorem. Hamilton cycles, Chinese-postman problem, approximate solutions of traveling salesman problem. Closest neighbour algorithm.

Matching and Colorings: Matchings, maximal matchings. Coverings and minimal coverings. Graph Dominations and Independent sets. Vertex colorings, Planar graphs. Euler theorem on planar graphs.

Large Scale networks: Introduction. Graph and Networks. Network topologies. Examples of large-scale networks and networked systems. Power Law distributions. Scale-free networks. Random graph models for large networks: Erdos-Renyi graphs, power-law graphs, small world graphs, phase transitions. Network stabilities.

Graph Networks and Centralities:. Degree and distance centralities. Closeness centrality. Betweeness centrality. Eigenvector centrality and Page ranking algorithm and applications. Clustering coefficient and clustering centrality. Introduction to community detections.

Case Studies: Implementation of the centralities and community detection algorithms with Transport networks, Biological networks, ect.,

TEXT BOOKS:
  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. *Networks: An Introduction* , M. E. J. Newman , Oxford University Press , 2010.

  4. *Complex Graphs and Networks* , F. Chung and L. Lu , American Mathematical Society , 2006

  5. *Graph Algorithms in Neo4j*

22MAT322   **Regression Analysis**   **3 0 2 4**

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.

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.

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.

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.

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.
Case studies with different data sets.

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. Keith McNulty, Handbook of Regression Modeling in People Analytics with Examples in R and Python, CRC Press, 2021.

4. Jeremy Arkes, Regression Analysis: A Practical Introduction, Taylor & Francis, 2019.
5. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012

22CSC311	Machine Learning	3 1 0 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.
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Hal Daumé III, A Course in Machine Learning, 2015.
5. Dirk P. Kroese, Zdravko Botev, Thomas Taimre, Radislav Vaisman, Data Science and Machine Learning, Mathematical and Statistical Methods, CRC Press, 2019.
6. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2014.

22CSC312   DATA VISUALIZATION   3 0 2 4

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

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.

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.

Text books / References:

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

2. Claus Wilke, Fundamentals of Data Visualization-A Primer on Making Informative and Compelling Figures, O'Reilly Media Publisher, 2019.
3. Kieran Healy, Data Visualization A Practical Introduction, Princeton University Press, 2018.
4. Chun-houh Chen, Wolfgang Hardle and Antony Unwin,"Handbook of Data Visualization", Springer, 2008

22CSC314 Data Governance, Ethics and Law   1 0 0 1

- An ethics-driven approach to Data Governance encourages sound knowledge of data, protection laws, and the appropriate use of the technology that generates, analyses and propagates data.

- Data gathering and tools for data gathering.

- Ethics in data collections and management.

- Data privacy and protections.

- Case Studies.

Reference Books:

1. Katherine O'Keefe, Daragh O Brien, Ethical Data and Information Management Concepts, Tools and Methods, Kogan Page publisher, 2018.
2. The Ethics of Biomedical Big Data, Springer, 2016.

22CSC313   Computer Networks 3 0 2 4

Course Outcomes:
1. Gain the knowledge of the basic computer network technology.
2. Gain the knowledge of the functions of each layer in the OSI and TCP/IP reference model.
3 Obtain the skills of subnetting and routing mechanisms.
4. Familiarity with the essential protocols of computer networks, and how they can be applied in network design and implementation.
Network hardware, Network software, OSI, TCP/IP Reference models, Example Networks: ARPANET, Internet. Physical Layer: Guided Transmission media: twisted pairs, coaxial cable, fiber optics, Wireless transmission.

Data link layer: Design issues, framing, Error detection and correction.
Elementary data link protocols: simplex protocol, A simplex stop and wait protocol for an error-free channel, A simplex stop and wait protocol for noisy channel.
Sliding Window protocols: A one-bit sliding window protocol, A protocol using Go-Back-N, A protocol using Selective Repeat, Example data link protocols.
Medium Access sub layer: The channel allocation problem, Multiple access protocols: ALOHA, Carrier sense multiple access protocols, collision free protocols. Wireless LANs, Data link layer switching.

Network Layer: Design issues, Routing algorithms: shortest path routing, Flooding, Hierarchical routing, Broadcast, Multicast, distance vector routing, Congestion Control Algorithms, Quality of Service, Internetworking, The Network layer in the internet.

Transport Layer: Transport Services, Elements of Transport protocols, Connection management, TCP and UDP protocols.

Application Layer –Domain name system, SNMP, Electronic Mail; the World WEB, HTTP, Streaming audio and video.

TEXT BOOK:

1. James Kurose and Keith Ross, *Computer Networking: A Top-Down Approach*, 7th edition, Person Edition, 2018.

REFERENCE BOOKS:

1. S. Keshav, An Engineering Approach to Computer Networks-, 2nd Edition, Pearson Education.

2. Behrouz A. Forouzan, Data Communications and Networking –. Third Edition TMH.

3. Andrew S Tanenbaum, David. j. Wetherall, Computer Networks, , 5th Edition. Pearson Education.

22CSC382   **Machine Learning Lab**   **0 0 2 1**

- Implementation of the FIND-Salgorithm for finding the most specific hypothesis based on a given set of training data samples.

- EM algorithm

- Implementation of the Locally weighted Regression algorithm

- Implementation of the Candidate-Elimination algorithm.

- Implementation of the K means algorithm

- Demonstration of the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

- Building an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets Back propagation Algorithm.

- Implementation of the naïve Bayesian classifier for a sample training data set.

- Implementation of the k-Nearest Neighbour algorithm to classify the data set.

- Implementation of the non-parametric Locally Weighted Regression algorithm in order to fit data points.

22MAT401   **Probabilistic Graphical Models for Data Science**   **3 0 2 4**

Fundamentals: Fundamentals of Probability Theory - Views of Probability, Random Variables and Joint Distributions, Conditional Probability, Conditional Independence, Expectation and Variance, Probability Distributions - Conjugate Priors, Introduction to Exponential Family; Fundamentals of Graph Theory - Paths, Cliques, Subgraphs, Cycles and Loops.

Graphical Models: Introduction - Directed Models (Bayesian Network), Undirected Models (Markov Random Fields), Dynamic Models (Hidden Markov Model & Kalman Filters) and Factor Graph; Conditional Independence (Bayes Ball Theorem and D-separation), Markov Blanket, Factorization (Hammersley-Clifford Theorem), Equivalence (I-Maps & Perfect Maps); Factor Graphs - Representation, Relation to Bayesian Network and Markov Random Field.

Inference in graphical models: Exact Inference - Variable Elimination, Elimination Orderings, Relation to Dynamic Programming, Dealing with Evidence, Forward-Backward Algorithm, Viterbi Algorithm; Junction Tree Algorithm; Belief Propagation (Sum Product); Approximate Inference - Variational Methods (Mean Field, Kikuchi & Bethe Approximation), Expectation Propagation, Gaussian Belief Propagation; MAP Inference - Max-Product, Graph Cuts, Linear Programming Relaxations to MAP (Tree-Reweighted Belief Propagation, MPLP); Sampling - Markov Chain Monte Carlo, Metropolis Hastings, Gibbs (Collapsing & Blocking), Particle filtering.

Learning in Graphical Models: Parameter Estimation - Expectation Maximization, Maximum Likelihood Estimation, Maximum Entropy, Pseudolikelihood, Bayesian Estimation, Conditional Likelihood, Structured Prediction; Learning with Approximate Inference; Learning with Latent Variables; Structure Learning, Structure Search, L1 priors.

Case studies.

Tools: SamIam   and OpenGM

Text Books: 1. Koller, D. and Friedman, N. (2009). Probabilistic Graphical Models: Principles and Techniques. MIT Press.

Reference Books:

1. Jensen, F. V. and Nielsen, T. D. (2002). Bayesian Networks and Decision Graphs. Information Science and Statistics. Springer, 2nd edition.
2. Kevin P. Murphy (2013) Machine Learning: A Probabilistic Perspective. 4th Printing. MIT Press.
3. Barber, D. (2011). Bayesian Reasoning and Machine Learning. Cambridge University Press, 1st edition.
4. Bishop, C. M. (2011). Pattern Recognition and Machine Learning (Information Science and Statistics). Springer, 2nd printing.
5. Wainwright, M. and Jordan, M. (2008). Graphical Models, Exponential Families, and Variational Inference. Foundations and Trends in Machine Learning, 1:1–305.

22CSC401   **Deep Learning**   **3 0 2 4**

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).

Convolutional Neural Networks: LeNet, AlexNet.

Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs

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.

Transformers: Transfer learning, data augmentation and hyperparameter search.

Applications: Vision, NLP, Speech (just an overview of different applications in 2-3 lectures)

Case Studies with Keras, MXNet, Deeplearning4j, Tensorflow, CNTK, or Theano.

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

22CSC403   **Reinforcement Learning**   **3 0 2 4**

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.

Eligibility Traces, Functional Approximation, Fitted Q, DQN & Policy Gradient for Full RL and Hierarchical RL.

Text Book:

1. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning:An Introduction, second edition, MIT Press, 2019.

References:

1. Phil Winder, Reinforcement Learning, O'Reilly Media Publisher, 2020.
2. Sudharsan Ravichandiran, Hand-on Reinforcement Learning with Python, Packt Publications, 2018.
3. Sayon Dutta, Reinforcement Learning with Tensor Flow: A beginner's guide, Packt Publications, 2018.

22CSC402   Practical Techniques for Big Data Analytics   3 0 2 4

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.

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.

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.

TEXT BOOK:

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.*

22CSC404   **Data Security**   **3 0 0 3**

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).

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

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

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

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

Text book:

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.

22CSC411   **Software Engineering**   **3 0 2 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

22CSC412   Deep Learning for Natural Language Processing   3 0 2 4

Introduction, Multilayer Neural Networks, Back-propagation.
Training Deep Networks; Simple word vector representations: word2vec.
GloVe; sentence, paragraph and document representations. Recurrent Neural
Networks; Convolutional Networks and Recursive Neural Networks; GRUs and
LSTMs; building attention models; memory networks for language understanding.

Design and Applications of Deep Nets to Language Modeling, parsing, sentiment analysis,
machine translation etc.

Case Studies: Convolutional Neural Networks, Text Classification Using Convolutional Neural
Networks, RNN and Natural Language Understanding in Conversational Systems.
TEXT BOOK:

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

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

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.

22CSC413   Internet of Things   1 0 2 2

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)

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).

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

Electives

22CSC541   **Soft Computing**   **2 0 2 3**

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.

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

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.

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.

22CSC542   **Cryptography**   **2 0 2 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

22CSC544 DEEP LEARNING FOR IMAGE PROCESSING 2 0 2 3

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.

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.

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.

Deep learning for visual data. Data-driven image classification, linear classification, activation functions, various cost functions, gradient-based optimization with backpropagation. Convolutional neural networks (CNN) and methods for training them, transfer learning and data augmentation. Different architectures and applications in image analysis (classification, detection, segmentation). Visualization and understanding of convolutional neural networks. Generative Adversarial Networks (GANs). Possibilities and limitations with deep learning.
Case Studies:

TEXT BOOK:
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.*

22CSC546   **Mining of Massive Datasets**   **2 0 2 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.

22CSC547   **Data Compression**   **2 0 2 3**

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.

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

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.

TEXT BOOK:
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.

22CSC551   Big Data Storage and Analysis   2 0 2 3

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,

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.

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

TEXT BOOK:

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/

22CSC548   Introduction to Embedded Systems   2 0 2 3

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

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.

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 Books:
>   1.Muhammad Ali Mazidi, Janice G. Mazidi, Rolin D. McKinlay - 8051 Microcontroller and Embedded Systems, The, 2nd Edition - 2006 – pearson
>   2.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), 3rdEd., 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.

22CSC549   **INFORMATION RETRIEVAL**   **2 0 2 3**

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.

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

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

TEXT BOOK:

Manning C D., Raghavan Pand Schutze 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.

22CSC550   **Social Network Analytics**   **2 0 2 3**

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

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

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 books:

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

22MAT439   COMPUTATIONAL GEOMETRY   2 0 2 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.

22MAT431   **Real Analysis**   **2-0-2-3**

Sets and Functions: The Completeness Property of – Applications of the Supremum Property – Applications of the Supremum Property.

Sequence: Sequence and Series: Sequences and their Limits – Limits Theorems – Monotone sequences. The Cauchy criterion – Properly divergence sequences.

Series: Introduction to series – Absolute Convergence – Tests for Absolute Convergence – Limit Comparison Test, Root Test, Ratio test, Integral Test, Raabe's Test – Tests for Non absolute Convergence.

Limits of Functions: – Limit Theorem – Some Extensions of the Limit Concept

Continuous Functions: – Continuous Functions -Continuous Functions on Intervals – Uniform Continuity –Monotone and Inverse Functions.

Text Book:

1. Robert G. Bartle and Donald R. Sherbert, "Introduction to Real Analysis", John Wiley and Sons, Third Edition, 2000.

Reference Book:

1. W J. Kaczor and M.T. Nowak, "Problems in Mathematical Analysis I - Real Numbers, Sequences and Series"; American Mathematical Society, 2000.

2. S. C. Malik and Savita Arora, "Mathematical Analysis", New Age International Publishers, Fourth Edition, 2012.

3. H.L. Royden and P. M. Fitzpatrick , "Real Analysis", Pearson Education Asia Limited, Fourth Edition, 2010.

4. S. Kumaresan and Ajit Kumar, *A Basic Course in Real Analysis*, CRC Press.

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.

22MAT433 **Transform Techniques** **2 0 2 3**

Laplace Transform : Laplace Transforms, Inverse Transforms, Linearity, Shifting, Transforms of Derivatives and Integrals, Differential Equations, Unit Step Function, Second Shifting Theorem, Dirac's Delta Function. Differentiation and Integration of Transforms. Convolution, Integral Equations, Partial Fractions, Differential Equations, Systems of Differential Equations.

Fourier Series: Fourier series, Half range Expansions, Parseval's Identity, Fourier Integrals, Fourier integral theorem. Sine and Cosine Integrals.

Fourier Transforms: Sine and Cosine Transforms, Properties, Convolution theorem**.**

Partial Differential Equations: Basic Concepts, Modeling; Vibrating String, Wave Equation, Separation of Variables, Use of Fourier Series, Heat Equation; Solution by Fourier Series.

Text Book:

1. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2016.

Reference Books:

1. Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012.

2. Engineering Mathematics, Srimanta Pal and Subodh c Bhunia, Oxford press, 2015.

3. Larry C. Andrews and Bhimson. K. Shivamoggi, The Integral Transforms for Engineers, Spie Press, Washington, 1999.

22MAT435	DIFFERENTIAL EQUATIONS	2 0 2 3

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)

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)

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).
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)
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)
TEXT BOOK:
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.

22MAT441   Theory of Sampling and Design of Experiments for Data Analysis   2 0 2 3

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.

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.

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

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

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.*

22MAT444   **Statistical Quality Control**   **2 0 2 3**

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

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.

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.

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.

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).*

22MAT436   **Random Processes for Data Analytics**   **2 0 2 3**

Random Processes – introduction, Classification – statistical properties – examples Stationary processes – SSS/WSS processes, Examples on SSS/WSS processes Properties of autocorrelation function – problems, Examples on WSS/Variance. Point process-Poisson process – concepts – properties Mean-autocorrelation of Poisson Process – proof Theorems on Poisson Process Problems on Poisson process Gaussian Process- First and Second order Process Properties - Problems. The spectrum estimation – concepts Mean ergodic theorem, Sufficient condition for Mean ergodicity - Problems Correlation ergodicity Problems Power spectral density (PSD) – concepts- properties, Weiner Kinchine theorem Problems on PSD. Markov Process – Chain – concepts, Chapman Kolmogorov theorem, steady state, Classification of states probabilities Problems on Markov chain.

Text Books:

1. A. Papoulis, and Unnikrishna Pillai, "*Probability, Random Variables and Stochastic Processes*", Fourth Edition, McGraw Hill, 2002.
2. J. Ravichandran, "Probability and Random Processes for Engineers", 1st Edition, IK International, 2015.

Books for Reference:

3. Sheldon M. Ross, "Stochastic Processes", 2ndEdition, Wiley, 1995.
4. J. Medhi, "Stochastic Processes", 2nd Edition, New Age International Private limited, 2006.
3. Roy D. Yates, David J. Goodman. (2005). *Probability and Stochastic Processes, A Friendly Introduction for Electrical and Computer Engineers*. John Wiley

22MAT437   **Time Series Analysis**   **2 0 2 3**

Introduction: Examples of time series, Stationary models and autocorrelation function, Estimation and elimination of trend and seasonal components.
Stationary Process and ARMA Models: Basic properties and linear processes, Introduction to ARMA models, properties of sample mean and autocorrelation
function, Forecasting stationary time series, ARMA(p, q) processes, ACF and PACF, Forecasting of ARMA processes.
 Modeling and Forecasting with ARMA Processes: Preliminary estimation, Maximum likelihood estimation, Diagnostics, Forecasting, Order selection.
Nonstationary and Seasonal Time Series Models: ARIMA models, Identification techniques, Unit roots in time series, Forecasting ARIMA models, Seasonal ARIMA models, Regression with ARMA errors.

Forecasting Techniques: The ARAR algorithm, The Holt-Winter algorithm, The Holt-Winter seasonal algorithm. Estimation of time series models.

Text Book:

1. Brockwell, Peter J. and Davis, Richard A. (2002). Introduction to Time Series and Forecasting, 2nd edition. Springer-Verlag, New York.

2. Robert H. Shumway and David S. Stoffer Time Series Analysis and Its Applications With R Examples, Springer, 2016.

References:
1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. (1994). Time Series Analysis: Forecasting and Control, 3rd Edition, Prentice Hall, New Jersey.
2. Chatfield, C. (1996). The Analysis of Time Series, 5th edition, Chapman and Hall, New York.
3. Shumway, R.H., Stoffer, D.S. (2006). Time Series Analysis and Its Applications (with R examples). Springer-Verlag, New York.
4. Avishek Pal and PKS Prakash, Practical Time Series Analysis, Birmingham - Mumbai, 2017.

5. Galit Shmueli and Kenneth C. Lichtendahl Jr (2016). Practical Time Series Forecasting with R: A Hands-On Guide, 2nd Edition, Axelrod Schnall Publishers.

22MAT438   **WAVELETS**   **2 0 2 3**

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

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

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

The Iteration Step for Wavelets on Z, Implementation and Examples.

$L_2(R)$ 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.

22MAT440   QUEUING THEORY AND INVENTORY CONTROL   2 0 2 3

Inventory concept – Components of Inventory model.

Deterministic Continuous Review model - Deterministic Periodic Review model.

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

Deterministic Multiechelon Inventory models for supply chain management.

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.

22MAT445   SIX SIGMA ANALYTICS   2 0 2 3

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

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

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

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

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).*

22MAT442   Data Analytics in Computational Biology   2 0 2 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.

22MAT443   Computer Aided Drug Designing   2 0 2 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

22MAT434 **ADVANCED BIG DATA ANALYTICS** **2-0-2-3**

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

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

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

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

Hierarchical clustering, Clustering algorithm to large dataset, classification using Navie bayes classifier, other applications.
Case Studies:

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.

22MAT446 **Statistical Pattern Recognition** **2-0-2-3**

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.

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

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.

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.

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.

Text books/ 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.*

22CSC552   **Full Stack Development**   **2 0 2 3**

The main objective of full stack engineer is to keep every part of the system running smoothly. A Full Stack Developer can performs tasks ranging from resizing an image or text in a webpage to patching the kernel.

1 : All-in-One JavaScript Development Suite

- Fundamentals of JavaScript
- JavaScript for Beginning Web Developers
- JavaScript for Absolute Beginners
- Fundamentals of jQuery
- Fundamentals of Ajax Development
- Create a node.js Real Time Chat Application
- Advanced JavaScript

2 : All-In-One HTML/HTML5 And CSS/CSS3 Suite

- All-In-One HTML/HTML5 And CSS/CSS3 Suite
- Applying Designs to WireFrames with HTML5 and CSS3
- Build Your Own HTML5 Video Player
- Building Responsive Websites with HTML5 and CSS3
- HTML5 and CSS3 Site Design
- HTML5 Mobile Game Development by Example - Educational Game

- HTML5 Mobile Game Development by Example -Veggies vs Zombies
- Make HTML5 Games with No Coding Required
- Understanding HTML5 Input Types
- Website Wireframing with HTML5 and CSS3

3 : Node.Js Training

- Introduction and Foundation
- Node Projects
- Working with shrink-wrap to lock the node modules versions
- Working with asynchronous programming
- Building a HTTP Server with Node.JS using HTTP APIs
- File System
- Buffers, Streams, and Events
- Multi-Processing in NodeJS
- ExpressJS
- Express JS with MongoDB and Sqlite
- io, The Front-end, and A Chat App
- Introduction to Task Managers with unit testing

4 : Angular Training

- What is a SPA? What is Angular?
- Preparing for TypeScript
- Angular-4 new features
- Building with A4 Components
- Bootstrap Scaffolding
- Angular 4 Binding and Events
- Dependency Injection and services
- Directives
- Pipes
- Forms
- HTTP, Promises, and Observables
- Testing

22CSC553   CLOUD COMPUTING   2 0 2 3

Cloud Computing Overview: Origins of Cloud computing – Cloud components - Essential characteristics – On-demand self- service, Broad network access, Location independent resource pooling ,Rapid elasticity, Measured service, Comparing cloud providers with traditional IT service providers, Roots of cloud computing.
Cloud Insights: Architectural influences – High-performance computing, Utility and Enterprise grid computing, Cloud scenarios – Benefits: scalability ,simplicity ,vendors ,security, Limitations – Sensitive information - Application development- security level of

third party - security benefits, Regularity issues: Government policies.
Cloud Architecture: Layers in cloud architecture, Software as a Service (SaaS), features of SaaS and benefits, Platform as a Service (PaaS), features of PaaS and benefits, Infrastructure as a Service (IaaS), features of IaaS and benefits, Service providers, challenges and risks in cloud adoption. Cloud deployment model: Public clouds – Private clouds – Community clouds - Hybrid clouds - Advantages of Cloud computing.
Cloud Simulators: CloudSim and GreenCloud: Introduction to Simulator, understanding CloudSim simulator, CloudSim Architecture(User code, CloudSim, GridSim, SimJava) Understanding Working platform for CloudSim, Introduction to GreenCloud
Module-V: Introduction to VMWare Simulator Basics of VMWare, advantages of VMware virtualization, using Vmware workstation, creating virtual machines-understanding virtual machines, create a new virtual machine on local host, cloning virtual machines, virtualize a physical machine, starting and stopping a virtual machine.

Text books / References:
1. Cloud computing a practical approach - Anthony T.Velte , Toby J. Velte Robert Elsenpeter, TATA McGraw- Hill , New Delhi – 2010
2. Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online - Michael Miller - Que 2008
References:
1. Cloud computing for dummies- Judith Hurwitz , Robin Bloor , Marcia Kaufman ,Fern Halper, Wiley Publishing, Inc, 2010
2. Cloud Computing (Principles and Paradigms), Edited by Rajkumar Buyya, James Broberg, Andrzej Goscinski, John Wiley & Sons, Inc. 2011.

22CSC556   HIGH PERFORMANCE COMPUTING   2 0 2 3

Parallel and Distributed Programming Models: Introduction to high performance computing, basic definitions: cluster, grid, meta-computing, middleware etc., examples of representative applications. Programming models: shared memory, message passing, peer-to-peer. Development of parallel and distributed applications, Design phases, Common parallel patterns, Performance metrics and profiling.

Overview of Cluster Computing: The Role of Clusters, Definition and Taxonomy, Distributed Computing, Limitations, Architecture of cluster-based systems, Design Decisions, Network Hardware, Network Software, Protocols Distributed File Systems, Virtualization technologies, Issues in cluster design: performance, single-system-image, fault tolerance, manageability, programmability, load balancing, security, storage.
Introduction of Grid Computing: Introduction, Evolution of the Grid, Definitions of Grid Computing, Infrastructure of hardware and software, Grid models, Applications, Examples of usage, Research possibilities / scope in Grid Computing, HPC and Grids, Scheduling HPC applications in Grids, Grid Monitoring Architecture (GMA) – An Overview of Grid Monitoring Systems.

Integrating task parallelism with data parallelism: Introduction and motivation, A model for integrating task parallelism into data parallel programming platforms, Integration of the model into ARC, Design and implementation applications, performance analysis, guidelines for composing user programs, related work.

Anonymous remote computing and communication model: Introduction, Location in dependent inter task communication with DP, DP model of iterative grid computations, Design and implementation of distributed pipes.

Text Books / References:
1. "Grid Computing a Research Monograph" by D. Janakiram, Tata McGraw hill publications
2. Joshy Joseph & Craig Fellenstein, "Grid Computing", Pearson Education
3. "Grid Computing: A Practical Guide to technology and Applications" by Ahmar Abbas, Charles River media.

22CSC554   **Data Wrangling**   **2 0 2 3**

INTRODUCTION TO DATA WRANGLING: What Is Data Wrangling?- Importance of Data Wrangling -How is Data Wrangling performed?- Tasks of Data Wrangling-Data Wrangling Tools-Introduction to Python-Python Basics-Data Meant to Be Read by Machines-CSV Data-JSON Data-XML Data.
WORKING WITH EXCEL FILES AND PDFS: Installing Python Packages-Parsing Excel Files-Parsing Excel Files -Getting Started with Parsing-PDFs and Problem Solving in Python-Programmatic Approaches to PDF Parsing-Converting PDF to Text-Parsing PDFs Using pdf miner-Acquiring and Storing Data-Databases: A Brief Introduction-Relational Databases: MySQL and PostgreSQL-Non-Relational Databases: NoSQL-When to Use a Simple File-Alternative Data Storage.
DATA CLEANUP: Why Clean Data?- Data Clean up Basics-Identifying Values for Data Clean up-Formatting Data-Finding Outliers and Bad Data-Finding Duplicates-Fuzzy Matching-RegEx Matching-Normalizing and Standardizing the Data-Saving the Data-Determining suitable Data Clean up-Scripting the Clean up-Testing with New Data
DATA EXPLORATION AND ANALYSIS: Exploring Data-Importing Data-Exploring Table Functions-Joining Numerous Datasets-Identifying Correlations-Identifying Outliers-Creating Groupings-Analyzing Data-Separating and Focusing the Data-Presenting Data-Visualizing the Data-Charts-Time-Related Data-Maps-Interactives-Words-Images, Video, and Illustrations-Presentation Tools-Publishing the Data-Open Source Platforms.
WEB SCRAPING: What to Scrape and How-Analyzing a Web Page-Network/Timeline-Interacting with JavaScript-In-Depth Analysis of a Page-Getting Pages-Reading a Web Page-Reading a Web Page with LXML-XPath-Advanced Web Scraping-Browser-Based Parsing-Screen Reading with Selenium-Screen Reading with Ghost. Py-Spidering the Web-Building a Spider with Scrapy-Crawling Whole Websites with Scrapy.

TEXT BOOKS:

1. Jacqueline Kazil & Katharine Jarmul," Data Wrangling with Python", O'Reilly Media, Inc, 2016.
REFERENCE BOOKS

1. Dr. Tirthajyoti Sarkar, Shubhadeep," Data Wrangling with Python: Creating actionable data from raw sources", Packt Publishing Ltd,2019.
2. Stefanie Molin," Hands-On Data Analysis with Pandas", Packt Publishing Ltd,2019
3. Allan Visochek," Practical Data Wrangling", Packt Publishing Ltd,2017.

22CSC555   Parallel and Distributed Systems 2 0 2 3

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.

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 -

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

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

22CSC557 Advance Deep Learning 2 0 2 3

Convolutional Neural Networks. Graph Convolutional Networks.

Residual Connections. Inception Module.

Functional API of Keras / Tensorflow 2.x

Transfer learning in CNN and RNN such as using image classifiers, text classification, sentimental analysis.

Attention models and Deep reinforcement learning. Generative models (Generative Adversarial Network).

tf.keras, TensorFlow Hub, and TensorFlow Lite tools.

Text / Reference Books:

1. Francios Chollet, *Deep Learning with Python* by.
2. Paolo Galeone, *Hands-On Neural Networks with TensorFlow 2.0*, by.
3. Michael Nielsen, *Neural Networks and Deep Learning*, by. Available for free online.
4. Goodfellow, Bengio, and Courville, *Deep Learning Book*, MIT Press.
5. R. Sutton and A. Barto, *Reinforcement Learning: An Introduction,* MIT Press.

22CSC543　　　　　BUSINESS ANALYTICS　　　　2 0 2 3
INTRODUCTION TO BUSINESS ANALYTICS:
Business Analytics - Terminologies, Process, Importance, Relationship with Organisational Decision Making, Analytics in Decision Making, BA for Competitive Advantage.
MANAGEING RESOURCES FOR BUSINESS ANALYTICS:
Managing BA Personnel, Data and Technology. Organisational Structures aligning BA. Managing Information policy, data quality and change in BA.
DESCRIPTIVE ANALYTICS:
Introduction to Descriptive analytics – Visualising, and Exploring Data - Descriptive Statistics - Sampling and Estimation - Probability Distribution for Descriptive Analytics - Analysis of Descriptive analytics.
PREDICTIVE ANALYTICS:
Introduction to Predictive analytics - Logic and Data Driven Models - Predictive Analysis Modeling and procedure - Data Mining for Predictive analytics. Analysis of Predictive analytics.
PRESCRITIVE ANALYTICS:
Introduction to Prescriptive analytics - Prescriptive Modeling - Non Linear Optimisation - Demonstrating Business Performance Improvement.
Case Studies:
Text books / References:
1. Marc J. Schniederjans, Dara G. Schniederjans and Christopher M. Starkey, " Business Analytics Principles, Concepts, and Applications - What, Why, and How" , Pearson Ed, 2014
2. Christian Albright S and Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", Fifth edition, Cengage Learning, 2015.

4. James R. Evans, "Business Analytics - Methods, Models and Decisions", Pearson Ed, 2012.

22CSC545　　　　　Predictive Analytics　　　　　2 0 2 3

Introduction to Data Mining Introduction, what is Data Mining? Concepts of Data mining, Technologies Used, Data Mining Process, KDD Process Model, CRISP – DM, Mining on various kinds of data, Applications of Data Mining, Challenges of Data Mining.

Data Understanding and Preparation Introduction, Reading data from various sources, Data visualization, Distributions and summary statistics, Relationships among variables, Extent of Missing Data. Segmentation, Outlier detection, Automated Data Preparation, Combining data files, Aggregate Data, Duplicate Removal, Sampling DATA, Data Caching, Partitioning data, Missing Values.

Model development & techniques Data Partitioning, Model selection, Model Development Techniques, Neural networks, Decision trees, Logistic regression, Discriminant analysis, Support vector machine, Bayesian Networks, Linear Regression, Cox Regression, Association rules.

Model Evaluation and Deployment Introduction, Model Validation, Rule Induction Using CHAID, Automating Models for Categorical and Continuous targets, Comparing and Combining Models, Evaluation Charts for Model Comparison, Meta Level Modeling, Deploying Model, Assessing Model Performance, Updating a Model.

Text Book / References:

1. Eric Siegel, Predictive Analytics, Wiley, 2021.

2. Jeffrey T. Prince and Amarnath Bose, A Predictive Analytics for Business Strategy - Reasoning from Data to Actionable Knowledge, Mc Graw Hill, 2020.

3.David L Olson, Data Mining Models, Business Expert Press, 2016