NATIONAL INSTITUTE OF TECHNOLOGY KURUKSHETRA

B.Tech.

in

MATHEMATICS AND COMPUTING

SCHEME OF INSTRUCTIONS AND SYLLABI

for B.Tech. Program

(Effective from Academic Year 2023-24)

DEPARTMENT OF MATHEMATICS

VISION AND MISSION OF THE INSTITUTE

National Institute of Technology Kurukshetra

VISION

To be a role model in technical education and research, responsive to global challenges.

MISSION

- To impart quality technical education that develops innovative professionals and entrepreneurs.
- To undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on socio-economic needs.

VISION AND MISSION OF THE DEPARTMENT

VISION

- To produce world-class engineers, creative technocrats, and professionals with outstanding mathematical backgrounds to meet global requirements.

MISSION

- To provide quality education and value-added services to the students and other stakeholders through formal and informal means of addressing and resolving their needs and undertaking innovative research that fulfills the futuristic socio-economic requirements.

AIMS AND OBJECTIVES OF DEPARTMENT

We are committed to fostering success for our students. As part of that commitment, the Department of Mathematics offers its students a number of services & facilities for their routine curriculum. Students seeking improvements in their basic mathematical skills find meaningful activities in the mathematics programs. The main objective of the mathematics Department is to produce engineering graduates performing excellently in Mathematics. The primary focus of the Mathematics Department is to be excellent in teaching Mathematics.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Equip students with a robust foundation in mathematics, computational techniques, and core engineering principles to solve complex problems in mathematics, computing, and interdisciplinary domains.

PEO2: Prepare graduates for successful careers in industries, research organizations, national and international laboratories, and academia by fostering deep learning, critical thinking, and innovative problem-solving abilities.

PEO3: Develop skills to communicate effectively, collaborate with multidisciplinary teams, and assume leadership roles in projects and organizations across diverse sectors.

PEO4: Instil the ability to evaluate and implement computing and mathematical solutions while upholding ethics, ensuring privacy and security, and addressing societal, environmental, and economic considerations.

PEO5: Encourage graduates to engage in lifelong learning, adapt to emerging technologies, and continuously enhance their knowledge and skills to meet evolving professional and societal demands.

PROGRAM OUTCOMES (POs)

PO1: Engineering knowledge

Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis

Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions

Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems

Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage

Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society

Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability

Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics

Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance

Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Mathematical Modelling and Algorithm Design

Apply advanced mathematical theories to design, analyze, and optimize algorithms for solving real-world computational and engineering problems efficiently.

PSO2: Integration of Mathematics and Computing

Develop a comprehensive understanding of mathematical frameworks and computational systems to design interfaces that seamlessly integrate subsystems in computing and engineering applications.

PSO3: Data Analytics and Decision-Making

Utilize statistical, probabilistic, and computational tools to analyze large datasets, extract meaningful insights, and develop data-driven solutions for complex engineering and interdisciplinary challenges.

PSO4: Innovative Computational Approaches

Leverage mathematical principles and computational techniques to create innovative algorithms, models, and systems for interdisciplinary applications, including artificial intelligence, machine learning, and scientific computing.

NATIONAL INSTITUTE OF TECHNOLOGY KURUKSHETRA

B.Tech. in Mathematics and Computing (M & C) Programme Scheme

Academic Year 2023-24 onwards

The Course Structure for B.Tech. Programme shall have the following categories of courses:

Sr. No.	Category
1	Institute Core (IC)
2	Non-Conventional Institute Core (NC)
3	Program Core (PC)
4	Program Elective (PE)
5	Open Elective (OE)

Course category explanation:

Course category	Explanation
IC	Basic Sciences
	Engineering Arts and Sciences
	Humanities and Social Sciences
PC	Courses specific to the relevant discipline
PE	Elective Courses specific to the relevant discipline
OE	Elective Courses from any domain
NC	Courses only qualifying in nature

Summary Sheet

Course Category	Semester								Total
	I	II	III	IV	V	VI	VII	VIII	
IC	19	12	-	-	-	-	3	-	34
PC	-	7	22	22	15	11	6	4/17	87/100
PE	-	-	-	-	3	7	7	7/0	24/17
OE	-	-	-	-	3	3	6	6/0	18/12
NC	2	2	-	-	-	2	-	-	6
Total	21	21	22	22	21	23	22	17	169

Semester – I

Course Category	S. No.	Course Code	Title	L	T	P	Credits
IC	1.	MAIC 101	Differential Calculus and Differential Equations	3	0	0	3
	2.	HSIC 101	Communication Skills in English	2	0	2	3#
		HSIC 103	Financial Education				
	3.	PHIC 101	Physics-I	3	0	2	4
	4.	MEIC 102	Engineering Practice	1	0	3	2
	5.	CSIC 101	Problems Solving and Programming Skills-I	3	0	2	4
	6.	CHIC 101	Energy and Environmental Science	2	0	2	3
NC	7.	HSNC 101	Human Values and Social Responsibility	2	0	0	2#
		HSNC 102	Sanskrit Language Skills				
		HSNC 103	Hindi Language Skills				
		HSNC 104	Telugu Language Skills				
		HSNC 105	Constitution of India				
		MANC 101	Vedic Mathematics				
	8.	SWMC101	NCC/NSS/Yoga	0	0	2	1*
	9.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1*
Total Credits							**21**

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of 6th semester based on Cumulative performance up to 6th semester.

Minimum number of students required to register for the subject to be offered is 50 and maximum number is 80 in one lecture group, limited to only 2 lecture groups for any subject.

@ In lieu of tutorial, wherever necessary, assignments and interactions with the students may be conducted at their own convenience by the faculty concerned.

Semester – II

Course Category	S. No.	Course Code	Title	L	T	P	Credits
IC	1.	MAIC 102	Integral Calculus and Difference Equations	3	0	0	3
	2.	HSIC 102	Economics for Engineers	3	0	0	3#
		HSIC 104	Business Studies				
	3.	CSIC 102	Engineering Graphics (Web Designing)^	1	0	2	2
	4.	CSIC 104	Programming Using Python	3	0	2	4
	5.	CSIC 100	Digital System Design	3	0	0	3
PC	6.	CSPC 100	Data Structures	3	0	2	4
NC	7.	HSNC 106	Indian Knowledge Systems	2	0	0	2#
		HSNC 107	Teachings of Gita				
		HSNC 108	French Language Skills				
		HSNC 109	German Language Skills				
		HSNC 110	Japanese Language Skills				
		HSNC 111	Thought Lab and Practices				
	8.	SWMC101	NCC/NSS/Yoga	0	0	2	1*
	9.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1*
Total Credits							**21**

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of the 6th semester based on Cumulative performance up to the 6th semester.

^Treated as a practical course (not integrated), the evaluation will be as per the practical course.

The minimum number of students required to register for the subject to be offered is 50, and the maximum number is 80 in one lecture group, which is limited to only 2 lecture groups for any subject.

@ In lieu of tutorial, wherever necessary, assignments and interactions with the students may be conducted at their own convenience by the faculty concerned.

Semester – III

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PC	1.	MAPC 201	Linear Algebra and Applications	3	0	0	3
	2.	MAPC 203	Discrete Mathematics	3	1	0	4
	3.	MAPC 205	Probability & Statistics	3	0	2	4
	4.	CSPC 201	Design and Analysis of Algorithms	3	0	2	4
	5.	CSPC 203	Computer Organization and Architecture	3	0	0	3
	6.	CSPC 205	Object Oriented Programming using Java	3	0	2	4
NC	7.	SWMC101	NCC/NSS/Yoga	0	0	2	1*
	8.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1*
Total Credits							**22**

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of 6^{th} semester based on Cumulative performance up to 6^{th} semester.

Semester – IV

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PC	1.	MAPC 202	Real and Complex Analysis	3	0	0	3
	2.	MAPC 204	Computer Oriented Numerical Methods	3	0	2	4
	3.	MAPC 206	Theory of Computation	3	0	0	3
	4.	CSPC 200	Operating Systems	3	0	2	4
	5.	CSPC 204	Artificial Intelligence and Soft Computing	3	0	2	4
	6.	CSPC 206	Data Base Management Systems	3	0	2	4
NC	7.	SWMC101	NCC/NSS/Yoga	0	0	2	1*
	8.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1*
MC	9.	**PC***	Minor course I	3	0	2	$3/4^{\#}$
Total Credits							**$22/26^{\#}$**

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of the 6th semester based on Cumulative performance up to the 6^{th} semester.

$Semester – V

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PC	1.	MAPC 301	Operations Research	3	0	0	3
	2.	MAPC 303	Scientific Computing	3	0	2	4
PE	3.	MAPE***	Program Elective I (Mathematics)	3	0	0	3
PC	4.	CSPC 204	Distributed Computing	3	0	0	3
	5.	CSPC***	Data Mining and Data Warehousing	3	0	2	4
IC	6.	CSIC301	Machine Learning	3	0	2	4
NC	7.	SWMC101	NCC/NSS/Yoga	0	0	2	1*
	8.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1*
MC	9.	**PC***	Minor course II	3	0	2	3/4#
Total Credits							**21/25#**

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of the 6th semester based on Cumulative performance up to the 6th semester.

$Semester – VI

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PC	1.	MAPC 302	Algebra and Computational Number Theory	3	1	0	4
	2.	MAPC 304	Graph Theory	3	0	0	3
	3.	CSPC 302	Big Data Analytics	3	0	2	4
PE	4.	MAPE***	Program Elective II (Mathematics)	3	0	0	3
	5.	CSPE***	Study Track Course I (Computing)	3	0	2	4
OE	6.	**OE**	Multidisciplinary/Open Elective-	3	0	0	3
NC	7.	SWMC101	NCC/NSS/Yoga	0	0	2	1
	8.	SWMC102	Sports/Clubs/Technical Societies	0	0	2	1
MC	9.	**PC***	Minor course III	3	0	2	3/4#
Total Credits							**23/27**
^Six-week internship during summer vacation Mandatory and it is to be evaluated in the VII semester.							

*Continuous Evaluation Model as per guidelines and the credit to be awarded at the end of the 6th semester based on Cumulative performance up to the 6th semester.

$Semester – VII

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PE	1.	MAPE***	Program Elective IV (Mathematics)	3	0	0	3
	2.	CSPE***	Study Track Course II (Computing)	3	0	2	4
OE	3.	**OE**	Multidisciplinary/Open Elective-II	3	0	0	3
	4.	**OE**	Multidisciplinary/Open Elective-III	3	0	0	3
IC	5.	**IC**	Entrepreneurship and Start-ups	3	0	0	3
PC	6.	MAPC 401	Project	0	0	6	6
MC	7.	**PC***	Minor course IV	3	0	2	3/4#
Total Credits							**22/26#**

^Six-week internship after IV Sem in the summer vacation is mandatory, and it is to be evaluated in the VII-Sem.

$Semester – VIII

Course Category	S. No.	Course Code	Title	Credits
PC	1.	MAPC 402	Internship*	17
Total Credits				**17**

OR

Course Category	S. No.	Course Code	Title	L	T	P	Credits
PC	1.	MAPC 402	Major Project	0	0	0	4
PE	2.	MAPE***	Program Elective (Mathematics)	3	0	0	3
	3.	CSPE***	Program Elective (Computing)	3	0	2	4
OE	4.	**OE**	Multidisciplinary/Open Elective-V	3	0	0	3
	5.	**OE**	Multidisciplinary/Open Elective-VI	3	0	0	3
Total Credits							**17**

$ - Tentative, yet to obtain the approval

Total Credits: 166/182#

Program Electives (Mathematics)

S. No.		Course Code	Course Title
1.	Program Elective I	MAPE 301	Fluid Dynamics
2.		MAPE 303	Mathematics of Data Science
3.		MAPE 305	Numerical Linear Algebra
4.		MAPE 307	Matrix Computation
5.		MAPE 309	Mathematical Modelling and Stimulation
6.		MAPE 311	Game Theory and Applications
7.		MAPE 313	Abstract Algebra
8.		MAPE 315	Applied Measure Theory
9.	Program Elective II	MAPE 302	Computational Fluid Dynamics
10.		MAPE 304	Finite Element Theory and Algorithms
11.		MAPE 306	Finite Volume Methods
12.		MAPE 308	Symbolic Computing
13.		MAPE 310	Cryptography
14.		MAPE 312	Fuzzy Mathematics
15.		MAPE 314	Optimization Techniques
16.		MAPE 401	Financial Mathematics

17.	Program Elective III	MAPE 403	Approximation Theory
18.		MAPE 405	Differential Geometry
19.		MAPE 407	Algebraic Coding Theory
20.		MAPE 409	Functional Analysis
21.		MAPE 411	Topology
22.		MAPE 413	Spectral Methods
23.		MAPE 415	Stochastic Process and Queueing Theory
24.		MAPE 417	Stochastic Differential Equations
25.		MAPE 419	Numerical Optimization
26.		MAPE 421	Statistical Stimulation and Data Analytics
27.		MAPE ***	Multigrid Methods
28.		MAPE ***	Time Series Analysis

Study Tracks (Computing)

S.No.	Study Tracks	Course Code	Track	Course Title
1.	Algorithms and Computing	CSTC 302	Course I	Randomized Algorithms and Probabilistic Analysis
2.		CSTC 304		High-Performance Computing
3.		CSTC 306		Distributed Blockchain Technologies
4.		CSTC 401	Course II	Parallel and Distributed Algorithms
5.		CSTC 403		Cloud Architecture and Networking
6.		CSTC 405		Quantum Computing
7.		CSTC 406		Cloud Computing
8.	Artificial Intelligence and Machine Learning	CSTC 308	Course I	Deep Learning
9.		CSTC 313		Pattern Recognition
10.		CSTC 310		Knowledge Representation and Reasoning
11.		CSTC 312		Information Retrieval
12.		CSTC 407	Course II	Cognitive Applications of ML
13.		CSTC 409		Natural Language Processing
14.	Data Science	CSTC 316	Course I	Optimization Techniques for Data Science
15.		CSTC 312		Information Retrieval
16.		CSTC 411	Course II	Semantic Web
17.		CSTC 413		Advances in Data Science
18.		CSTC 415		Nature-inspired Optimization Techniques
19.		CSTC 416		Data Visualization
20.		CSTC 417		Generative AI

Program Electives (Computing)

S.No.	Course Code	Course Title
1	CSPE***	Mathematics for Visual Computing
2	CSPE 407	Medical Image computing
3	CSPE 302	Advanced Data Base Management Systems
4	CSPE ***	Internet of Things
5	CSPE ***	Information Security

Division	Sub Division	Credits
Institute Core	Core Courses (IC)	37
	Mandatory Courses (MC)	6/16#
Program Core	Program Core (PC) – Mathematics	40
	Program Core (PC) – Computing	38
	Major Project / Internship	19
Electives	Program Elective (PE) – Mathematics	9
	Program Elective (PE) – Computing	8
	Multidisciplinary/Open Electives	12

Note: In addition to the above-listed electives, a student may register for electives (Program electives/Open electives) from SWAYAM-NPTEL courses on satisfying the minimum pre-requisite of the specific course(s) with the approval of DAC. Minor Courses – I, II, III, IV are meant for Minor Degree.

SWAYAM / NPTEL COURSES:

1. A student may complete SWAYAM - NPTEL courses and transfer equivalent credits to partially complete the mandatory credit requirements of the B. Tech. Program.
2. The Department may permit students to register from other platforms by taking care of evaluation and grading.
3. Before the commencement of each Semester, the Department shall release a list of SWAYAM - NPTEL courses approved as Elective/Open Elective courses.
4. A student shall only request for transfer of credits from such notified SWAYAM - NPTEL Courses as published by the Department.
5. SWAYAM - NPTEL Courses are considered for transfer of credits only if the concerned student has successfully completed and obtained the SWAYAM - NPTEL Certificate to this effect.
6. A student cannot transfer credits from SWAYAM – NPTEL Courses for any other type of Courses not permitted in the Curriculum.
7. Students shall register for the approved Courses as per the schedule announced by SWAYAM - NPTEL with the approval of DAC.
8. Any candidate can opt for only up to 20% of the total courses offered in a particular program in a semester through the online learning courses provided through the SWAYAM platform.
9. If a 4-credit course is not available as per the choice of the student, then he can opt for a 3-credit course that is available, and 1 credit will have to be acquired through continuous internal evaluation through a mentor.
10. If a 3-credit course is not available as per the choice of the student, then he can opt for a 2-credit course that is available, and 1 credit will have to be acquired through continuous internal evaluation through a mentor.
11. Students who have qualified in the proctored examination conducted by the SWAYAM - NPTEL and apply for credit transfer as specified are exempted from appearing in the continuous and semester-end evaluations (internal as well as external for the specified equivalent credit course only) conducted by the university.

12. If a student fails the opted SWAYAM course, s/he will have two choices: he can opt for another SWAYAM course of equivalent credit in the next semester or revert to the traditional exempted course offered by the university. Such student's claim to attend classes for the said course and undergo continuous assessment will remain unaffected. Such a student can undertake the traditional course under the mentor in the immediate succeeding semester to avoid any semester loss.
13. The credit equivalence for SWAYAM - NPTEL Courses: 12 weeks 4 credits, 6/8 weeks 3 credits; 4 weeks 1 credits.
14. The grading system for such SWAYAM - NPTEL Courses with the transfer of credits is specified in the Table given below:

Table: Grading System for SWAYAM – NPTEL Courses

Final Score on the SWAYAM-NPTEL Certificate	**Grade Awarded**
Final Score $\geq$ 85	A+
75 $\leq$ Final Score < 85	A
65 $\leq$ Final Score < 75	B
50 $\leq$ Final Score < 65	C
40 $\leq$ Final Score < 50	D
Final Score < 40	F

15. A student must submit the original SWAYAM - NPTEL Course. Certificates to the Head of the Department concerned, with a written request for the transfer of the equivalent credits. On verification of the SWAYAM - NPTEL Course Certificates and approval by the Head of the Department, the SWAYAM - NPTEL. Course(s) and equivalent Credits will be included in Course (with associated Credits) Registration of the concerned student in the Semester immediately following the completion of the SWAYAM - NPTEL Course(s).
16. A student may submit a request for credit transfer from SWAYAM - NPTEL Courses before the last instruction day of the Eighth (8th) Semester of the B. Tech program as specified in the Academic Calendar.
17. The Institute shall not reimburse any fees/expenses a student may incur for the SWAYAM - NPTEL courses.

SYLLABUS

SEMESTER III

Course Code:	MAPC 201	**Pre-requisites:**	NIL
Course Title:	Linear Algebra & Applications	**L-T-P-C**	3-0-0-3

Course Objectives:

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

CO1	Solve linear systems using matrices, row operations, LU Decomposition, and apply them to real-world problems.
CO2	Understand vector spaces by exploring fields, subspaces, linear independence, basis, dimension, and their applications to engineering
CO3	Analyze linear transformations, focusing on rank, nullity, isomorphisms, eigenvalues, eigenvectors, and their applications to dynamical systems and differential equations.
CO4	Study eigen decomposition and matrix theory, including diagonalizability, the Primary Decomposition Theorem.
CO5	Master inner product spaces through Gram-Schmidt orthogonalization, least square problems, and applications of SVD, spectral decomposition, and operator theory.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO3	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO4	2	1	1	-	1	-	-	-	-	-	-	-	1	-	-	1
CO5	2	2	1	-	2	-	-	-	-	-	-	-	3	-	-	1

3 ⟶ Strongly Correlated; 2 ⟶ Moderately Correlated; 1 ⟶ Weakly Correlated; - ⟶ No Direct Correlation

Syllabus:

Unit 1: **10L**

System of Linear Equations: Matrices and elementary row operations, Row reduced echelon matrices, Homogeneous system of linear equations, Elementary matrices, LU Decomposition, some applications giving rise to Linear Systems Problems.

Unit 2: **10L**

Vector Space: Fields, fields of numbers, finite fields, Vector Spaces over R and C, subspaces, linear independence, basis and dimension of a vector space, ordered basis and coordinates, Application to difference equations and Markov chains.

Unit 3: **10L**

Linear Transformation: Linear transformations, Rank and Nullity of linear transformation, Algebra of linear transformation, Isomorphism, Invertible linear transformations, Dual and double dual of a vector space and transpose of a linear transformation, Matrix representation of Linear Transformation, eigenvalue and eigenvector of a linear transformation, Discrete dynamical systems, Application to differential equations.

Unit 4: **10L**

Eigen Decomposition: Diagonalizability of linear operators of finite dimensional vector spaces, simultaneous triangularization and simultaneous diagonalization, Primary decomposition theorem - diagonal and nilpotent parts, Applications to Image processing and Statistics.

Inner Product Spaces: Gram-Schmidt orthogonalization, best approximation of a vector by a vector belonging a given subspace and application to least square problems, Adjoint of an operator, Hermitian, unitary and normal operators, Singular Value Decomposition and its applications, Spectral decomposition, Applications of Inner product spaces.

Text Books:

1. G. Strang, Linear Algebra and its Applications, Cengage.
2. D.C. Lay, Linear Algebra and its Applications, Pearson.
3. K. Hoffman, R. Kunze, Linear Algebra, Pearson.

Reference Books:

1. D. Poole, Linear Algebra: A Modern Introduction, Brooks/Cole.
2. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice-Hall of India.
3. S. Lang, Linear algebra (undergraduate text in mathematics), Springer.

Course Code:	MAPC 203	**Pre-Requisites:**	NIL
Course Title:	Discrete Mathematics	**L-T-P-C**	3-1-0-4

Course Objectives:

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

CO1	Understand and apply fundamental concepts of mathematical logic, including propositional and predicate logic, tautologies, and inference techniques.
CO2	Analyze and solve combinatorial problems using counting principles, permutations, combinations, and recurrence relations.
CO3	Explore and apply relations concepts, including binary relations, equivalence relations, and ordering relations, with their matrix representations.
CO4	Analyze the group's structure and identify its potential subgroups.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1: **10L**

Mathematical Logic: Connectives, Tautologies, Equivalence of formulas, Duality law, Tautological implications, Normal forms, Theory of inference for statement calculus, Methods of proof, Predicative logic, Statement functions, Variables, and quantifiers, Free and bound variables, Inference theory for predicate calculus.

Unit 2: **10L**

Counting: Basics of counting, Permutations, and combinations - Generalized Permutations and combinations, Pascal's identity, Vandermonde identity, the principles of inclusion & exclusion, the Pigeon-hole principle, and its applications.

Unit 3: **10L**

Recurrence Relations: Generating functions, Generating functions of permutations and combinations, Formulation as recurrence relations, Solving recurrence relations by substitution and generating functions, Method of characteristic roots, Solving inhomogeneous recurrence relations, Applications of recurrence relations.

Relations: Binary relations, Properties of binary relations, Equivalence relations and partitions, Matrix representation of relations, Adjacency matrices, Incidence matrices, Transitive closure, Warshall algorithm, Partial and total ordering relations, Lattices.

Unit 4: **10L**

Groups: Binary operations, Groups, subgroups, cyclic groups – definition, examples, results;, symmetricgroups, Cosets of a group; Lagrange's Theorem and its consequences on finite groups; a counting principle; Normal Subgroups and Quotient Groups; Centralizers, Normalizers, Centre of a group.

Mappings between Groups: Homomorphism between groups, the kernel of a group, isomorphism, fundamental theorem of isomorphism on groups; Groups of permutations and Cayley's Theorem; Orbits, cycles, and the alternating groups.

Text Books:

1. J. R. Mott, A. Kandel and Baker, Discrete Mathematics for Computer Scientists, PHI, 2006.
2. C. L. Liu, Elements of Discrete Mathematics, McGraw Hill, 1985.
3. J. P. Tremblay and R. Manohar, Discrete Mathematics with applications to Computer Science, Tata McGraw-Hill, 1997.

Reference Books:

1. K. H. Rosen, Discrete Mathematics and its Applications with Combinatorics and Graph Theory, Tata McGraw Hill, Seventh Edition, 2015.
2. Bernand Kolman, Robert C. Busby and Sharon Cutler Ross, Discrete Mathematical Structures, PHI, Sixth Edition, 2009.
3. R. Balakrishnan and K. Ranganathan, A Text Book of Graph Theory, Springer, 2000.
4. I. N. Herstein, Topics in Algebra, Wiley, 1975, Second Edition.
5. John B. Fraleigh, A First Course in Abstract Algebra, Pearson, 2013, Seventh Edition.
6. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning, 2013, Eighth Edition

Course Code:	MAPC 205	**Pre-Requisites:**	NIL
Course Title:	Probability & Statistics	**L-T-P-C**	3-0-2-4

Course Objectives: At the end of the course, the students will be able to:

CO1	Understand and analyze probability distributions, random variables, and mathematical expectation, including their applications in statistical modeling.
CO2	Apply and evaluate theoretical probability distributions, including Binomial, Poisson, Normal, and Gamma distributions, for empirical data fitting.
CO3	Perform hypothesis testing and estimation using statistical methods such as t-tests, Chi-square tests, F-tests, and ANOVA for data-driven decision-making.
CO4	Explore and implement correlation, regression analysis, and least squares methods for predictive modeling and statistical inference.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1: **10L**

Random Variables: Review of probability, Probability distributions with discrete and continuous random variables, Joint probability mass function, Marginal distribution function, Joint density function Independent random variables, Mathematical Expectation, Moment generating function, Chebyshev's inequality, Weak law of large numbers, Bernoulli trials.

Unit 2: **10L**

Theoretical Probability Distributions: Binomial, Negative Binomial, Geometric, Poisson, Normal, Rectangular, Exponential, Gaussian, Beta, and Gamma distributions and their moment generating functions, Fit of a given theoretical model to empirical data.

Unit 3: **10L**

Sampling and Testing of Hypothesis: Introduction to testing of hypothesis - Tests of significance for large samples t, F and Chi-square tests, ANOVA - one-way and two-way classifications.

Unit 4: **10L**

Theory of Estimation: Characteristics of estimation, Minimum variance unbiased estimator, Method of maximum likelihood estimation.

Correlation and Regression: Scatter diagram, Linear and polynomial fitting by the method of least squares, Linear correlation and linear regression, Rank correlation, Correlation of bivariate frequency distribution.

Laboratory:

Students can write computer programs.

1. Calculation of A.M., G.M., H.M., median, and mode.
2. Calculation of quartiles, deciles and percentiles.
3. Calculation of range, quartile deviation, mean deviation, standard deviation, and root mean square deviations.
4. Calculation of central moments from raw moments, calculation of skewness and kurtosis.
5. Calculation of raw moments from central moments, calculation of moments about one point from moments about another point.
6. Fitting of binomial distribution.
7. Fitting of Poisson distribution.
8. Fitting of normal distribution.
9. Testing of hypothesis based on normal distribution.
10. Test based on chi-square distribution.
11. Test based on t-distribution.
12. Test based on F-distribution.
13. Test based on ANOVA

Text Books:

1. S.C. Gupta and V.K. Kapur, Fundamentals of Mathematical Statistics, S. Chand & Sons, New Delhi, 2008.
2. V.K. Rohatgi and A.K. Md. Ehsanes Saleh, An Introduction to Probability Theory and Mathematical Sciences, Wiley, 2001.

Reference Books:

1. Miller & Freund's Probability and Statistics for Engineers, Richard A. Johnson, Pearson, 2018, Ninth Edition.

Course Code:	CSPC 201	**Pre-Requisites:**	NIL
Course Title:	Design and Analysis of Algorithms	**L-T-P-C**	3-0-2-4

Course Objectives:

At the end of the course, the student will be able to:

CO1	Able to design, implement, and analyze standard searching and sorting algorithms.
CO2	Implement standard divide and conquer, Dynamic programming, Greedy and backtracking algorithms to solve real-world problems.
CO3	Able to implement between different data structures, i.e., trees, heaps, etc., also, able to pick an appropriate data structure for any given design situation.
CO4	Able to implement the major graph algorithms and their analysis.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

1. **Introduction**
   Concept of Time and space complexity, analysis of algorithms, asymptotic notation, recurrence relations, design and analysis of D & C problems like quick sort etc, heap sort, priority queues, sorting in linear time, hashing, binary search trees.
2. **Graph Algorithms**
   Graph representation & traversal (search), topological sort, strongly connected components, minimum spanning trees – Kruskal and Prim's, Single source shortest paths, relaxation, Dijkstra's algorithm, Bellman-Ford algorithm, single source shortest paths for directed acyclic graphs, all-pairs shortest path.
3. **B-Trees and Dynamic programming**
   B-Trees: representation and operations; Elements of Dynamic Programming, structure and steps, Matrix-chain multiplication, longest common subsequence.
4. **Greedy & Backtracking Approaches:**
   Greedy algorithms – Elements, activity-selection problem, Huffman codes, task scheduling problem, Knapsack Problem, Backtracking – Elements, 8 – Queens, Graph Coloring, Hamiltonian Cycles.

Text Books:

1. Cormen, Leiserson and Rivest: Introduction to Algorithms, 3/e, PHI.
2. Horowitz, Sahni, and Rajasekaran: Fundamentals of Computer Algorithms, Second Edition, Universities Press, Hyderabad.
3. Aho, Hopcroft, and Ullman: The Design and Analysis of Computer Algorithms, Addison Wesley.

Course Code:	CSPC 203	**Pre-Requisites:**	Digital System Design
Course Title:	Computer Organization and Architecture	**L-T-P-C:**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to:

CO1	Understand and analyze fundamental concepts of digital electronics, data representation, and machine-level programming.
CO2	Apply processor design principles, including instruction cycles, addressing modes, arithmetic operations, and pipelining for performance enhancement.
CO3	Evaluate and design control unit mechanisms using hardware and microprogrammed control methods.
CO4	Analyze memory hierarchy, I/O systems, and system organization to optimize data processing and storage efficiency.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

1. **Introduction**
   Introduction to digital electronics: combinational circuits and sequential circuits. Basic Machine Principle, Structure, and representation of real-world data. Subroutine, Branching & Macro facility.
2. **Processor Design**
   Processor Organization, Information representation and Number format, Instruction cycle, and Instruction format, Addressing modes, Arithmetic operation, timed point addition, subtraction, multiplication, and division, ALU design, Parallel processing – Performance consideration, Pipeline processor.
3. **Control Design**
   Instruction sequencing and Interpretation, Hardware Control design method, and Microprogrammed Control.
4. **Memory Organization**
   Memory device characteristics, Random access and serial access memories, Virtual memory – memory hierarchies, Page replacement policies, Segments, pages and file organization, High-speed memories – cache and associative memory.
5. **System Organization**
   Programmed I/O, DMA, and interrupts, I/O processors & CPU – I/O interaction.

Text Books:

1. John L. Hennessy, David A. Patterson: Computer Architecture: A Quantitative Approach, Sixth Edition, Morgan Kaufmann.
2. Kai Hwang: Computer Architecture and Parallel Processing, McGraw Hill Education.
3. M.M. Mano: Computer System Architecture, 3rd Ed. PHI.
4. J.P. Hayes: Computer Architecture and Organization, 3rd Ed. TMH,
5. C.W. Gear: Computer organization and Programming, TMH.
6. A.S. Tanenbaum: Computer System Organization, PHI

Course Code:	CSPC 205	**Pre-Requisites:**	NIL
Course Title:	Object-Oriented Programming using Java	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand and apply Java programming fundamentals, including object-oriented concepts, classes, objects, constructors, arrays, and method overloading.
CO2	Analyze and implement Java features such as packages, exception handling, interfaces, and polymorphism for modular and efficient programming.
CO3	Develop and execute multithreaded applications, event handling, and graphical user interfaces using Java FX for real-world applications.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

1. The overview of Java's architecture and the architecture of the Java Virtual Machine (JVM).
Classes: Declaring Members (Fields and Methods), Instance Members, Static Members.
Objects: Class Instantiation, Reference Values, and References, Object Aliases. Basic Language Elements, Primitive Data Types, Variable Declarations, Initial Values for Variables, Class Declarations, Method Declarations, this reference, Method Overloading, Constructors, The Default Constructor and Constructors overloading. Arrays, Anonymous Arrays, Multidimensional Arrays, Variable Arity Methods, The main() Method, Program Arguments.

2. **Packages:** Defining Packages, Using Packages, Compiling Code into Packages, Running Code from Packages. Scope Rules, Accessibility Modifiers, Overview of other Modifiers for Members.Operators and Expressions**,** Overview of Control Flow Statements.

3. **Exception Handling:** The try Block, The catch Block, The finally Block, The throw Statement, The throws Clause, Checked and Unchecked Exceptions, Defining New Exceptions.

4. **Object-Oriented Programming:** Single Implementation Inheritance, Overriding Methods, Hiding Members, The Object Reference super, Chaining Constructors Using this() and super()
Interfaces: Defining Interfaces, Abstract Method Declarations, Implementing Interfaces, Extending Interfaces, Interface References, Constants in Interfaces, Polymorphism and Dynamic Method Lookup.
Fundamental Classes: Overview of the java.lang Package, The Object Class, The Wrapper Classes, The String Class, The StringBuilder and the StringBuffer Classes.

5. **Multithreading:** Overview of Threads, the Main Thread, Thread Creation, Synchronization, Thread Transitions. Basics of Event Handling, Graphics Programming using Java Fx.

Text/Reference Books:

1. Y. Daniel Liang: Introduction to Java Programming, Comprehensive Version, Pearson Education, 12th Ed.
2. Bruce Eckel, Thinking In Java, Pearson Education, 4th Ed., 2006.
3. Dietel & Deitel, Java How to Program, Pearson Education, 10th Ed., 2015.
4. Kathy Sierra & Bert Bates, Head First Java, O'REILLY, 2nd Ed., 2005.
5. Cay s. Horstmann & Gary Cornell, Core Java. Volume I, Fundamentals, Sun Microsystems Press, 8th Ed., 2008.

SEMESTER IV

Course Code:	MAPC 202	**Pre-Requisites:**	NIL
Course Title:	Real and Complex Analysis	**L-T-P-C:**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand and analyze fundamental concepts of real analysis, including topology, sequences, series, limits, and uniform convergence.
CO2	Evaluate and apply Riemann-Stieltjes integrals and improper integrals, ensuring comprehension of their convergence properties.
CO3	Explore and utilize complex function theory, including analytic functions, differentiability, and contour integration.
CO4	Analyze and apply Taylor and Laurent series, singularities, and residue calculus for solving complex function problems.
CO5	Implement conformal mapping techniques for transformations, representation of regions, and analytic continuation in complex analysis.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO3	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO4	2	1	1	-	1	-	-	-	-	-	-	-	1	-	-	1
CO5	2	2	1	-	2	-	-	-	-	-	-	-	3	-	-	1

Syllabus:

Real Analysis: **15L**

Basic Set Topology: Interior points, open set, closed set, bounded set, compact set, region, connected region, simply connected region, boundary.

Sequences and Series: Sub-sequences, Convergent sequences, Cauchy criterion for sequences, Infinite Series, Convergence of series, Cauchy criterion for series, Comparison Tests, Ratio Test, Root Test.

Limits: formal definition, continuity, continuous curves.

Riemann Stieltje's integral: Definition and existence of the integral, Properties of the integral, Integration and differentiation of integrals with variable limits.

Improper integrals: Definitions and their convergence, Tests of convergence.

Uniform convergence: Tests for uniform convergence, Theorems on limit and continuity of sum functions, Term by term differentiation, and integration of series of functions.

Power series: Convergence and their properties.

Complex Analysis: **25L**

Functions of Complex Variables: Complex variable - Functions of a complex variable - Continuity - Differentiability – Analytic functions.

Complex Integration: Cauchy's theorem - Cauchy's integral formula - Morera's theorem - Cauchy's inequality - Liouville's theorem.

Series Expansions: Taylor's theorem - Laurent's theorem - Zeros of an analytic function - Singularities

Contour Integration: Residue - Cauchy's residue theorem – contour integration – the fundamental theorem of algebra - Poisson's integral formula. Analytic continuation – branches of a many-valued function - Riemann surface.

Conformal Mapping: The maximum modulus theorem - mean values of f(z) – Conformal representation – Bilinear transformation - Transformation by elementary functions - uniqueness of conformal transformation - representation of any region on a circle.

Text Books:

1. Principles of Mathematical Analysis, Walter Rudin, McGraw Hill, 2017, Third Edition.
2. Real Analysis, Brian S.Thomson, Andrew M.Bruckner, Judith B.Bruner, Prentice Hall International, 2008.
3. Complex Variables and Applications, R.V. Churchill and J.W. Brown, McGraw Hill, Tokyo, 2009, Eighth Edition.
4. Theory of Complex Variables, E.T. Copson, Oxford University Press, New Delhi, 1974.

Reference Books:

1. Real Analysis, N.L. Carothers, Cambridge University Press, 2000
2. Mathematical Analysis, Tom M. Apostol, Addison Wesley, 1974, Second Edition
3. Complex Variables with Applications, S. Ponnusamy & Herb Silverman, Birkhauser, Boston, 2006, First Edition
4. Complex Variable, Murray Spiegel, Seymour Lipschutz, John Schiller and Dennis Spellman, Schaum's Outlines Series, McGraw Hill, 2017, Revised Second Edition

Course Code:	MAPC 204	**Pre-Requisites:**	NIL
Course Title:	Computer-Oriented Numerical Methods	**L-T-P-C:**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand and analyze number systems, floating-point representation, and error types in numerical computations.
CO2	Apply iterative methods such as Bisection, Regula-Falsi, Newton-Raphson, and Gauss-Seidel to solve equations and eigenvalue problems.
CO3	Implement interpolation techniques, including Newton's and Lagrange's methods for function approximation and error estimation.
CO4	Utilize numerical differentiation and integration methods like finite differences, Newton-Cotes formulas, and Gauss quadrature for solving real-world problems.
CO5	Solve differential equations numerically using Picard's, Taylor's, Euler's, and Runge-Kutta methods for initial value problems.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	3	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3
CO5	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1 (Computer Arithmetic, Approximation and Errors) Number system, Conversion of numbers, Representation of numbers, Floating point representation, Arithmetic operations with Normalized floating point numbers, consequences of normalization, pitfalls of computing, significant digits, types of errors, absolute and relative error.

Unit 2 (Iterative Methods) Introduction, Order of convergence, Method of Bisection, Regula-Falsi Method or Method of False Position, Fixed-Point Iteration, Newton - Raphson Method, Secant Method, Generalized Newtons Method, Solution of linear system of equations, Gauss-Jacobi and Gauss-Seidel method, iteration methods, Eigen values and eigen vectors using Power method.

Unit 3 (Interpolation) Finite difference operators, Divided difference operators, Relation between difference operators, Application of difference operators, Polynomial Interpolation, Existence and uniqueness of interpolating polynomials, Lagrange and Newtons interpolation, Newtons forward and backward difference formula, Error in interpolation.

Unit 4 (Numerical Differentiation and Integration)

Numerical differentiation: Methods based on interpolation and finite differences, Error in approximation, Order of approximation.

Numerical Integration: Quadrature formula, Newton Cotes Methods, Trapezoidal and Simpson's rules with error analysis. Gauss quadrature methods with error analysis.

Unit 5 (Numerical Solution of Differential Equations) Picard’s method, Taylor's series method, Euler and Runge-Kutta methods for initial value problems of order one and higher, and system of first-order ODEs.

Practicals:

Students can use the PYTHON programming language

1. To solve nonlinear equations.
2. To solve a system of nonlinear equations.
3. To solve a system of linear equations using direct methods.
4. To solve a system of linear equations using indirect methods.
5. To find the eigenvalue of a matrix.
6. To make a difference table.
7. For interpolating arbitrary spaced and equally spaced data.
8. To approximate the derivative numerically.
9. To integrate a function numerically.
10. To solve the initial value problems of order one and more and system of first order ODEs.

Text Books:

1. M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Engineers and Scientists, New Age International, 2008.
2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1984.

Reference Books:

1. D. Atkinson, Numerical Analysis, John Wiley and Sons, 2009.
2. C. E Gerald, P. O. Wheatley, Applied Numerical Analysis, Pearson Edu. 2004.

Course Code:	MAPC 206	**Pre-Requisites:**	NIL
Course Title:	Theory of Computation	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Understand and analyze finite state machines, including deterministic/non-deterministic automata, transition systems, and minimization techniques.
CO2	Develop formal models for computational problems using regular expressions, grammars, and the Chomsky hierarchy.
CO3	Apply and evaluate Turing machines and Pushdown Automata for language recognition, problem-solving, and computability analysis.
CO4	Classify computational problems based on complexity theory, including time-space trade-offs, complexity classes, and undecidability.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	3
CO3	3	3	3	2	2	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1: **10L**

Machines: Basic machine, FSM, Transition graph, Transition matrix, Deterministic and non-deterministic FSMS, Equivalence of DFA and NDFA, Mealy & Moore machines, minimization of finite automata, Two-way finite automata.

Unit 2: **10L**

Grammars: Regular Sets and Regular Grammars: Alphabet, words, Operations, Regular sets, Finite automata and regular expression, Pumping lemma and regular sets, Application of pumping lemma, closure properties of regular sets.

Formal Grammars & Languages: Basic definitions and examples of languages, Chomsky hierarchy, Regular grammars, context free & context sensitive grammars, context free languages, non-context free languages, Chomskey normal forms, binary operations on languages.

Unit 3: **10L**

Turing Machines & Pushdown Automata: TM model, representation and languages acceptability of TM Design of TM, Universal TM & Other modification, composite & iterated TM, Pushdown automata, Acceptance by PDA.

Computability and Undecidability: Basic concepts, primitive & partial recursive function, Recursive function, Decidability, Kleens theorem, Undecidability, Properties of recursive & recursively enumerable languages, Universal Turing machine and undecidable problem, Rice's theorem & some more undecidable problems.

Unit 4: 10L

Computational Complexity Theory: Definition, linear speed-up, tape compression & reduction in number of tapes, Hierarchy Theorem, Relation among complexity measures, Transition lemmas & non-deterministic hierarchies, properties of general complexity measures, the gap, speed-up, union theorem, Automatic complexity theorem.

Text Books:

1. J. E. Hopcroft, J.D. Ullman, Introduction to Automata Theory, Languages & Computations, Narosa Publishers.
2. K.L.P. Mishra, Theory of Computer Science, Prentice Hall of India.

Reference Books:

1. E.V. Krishnamurthy, Introductory Theory of Computer science, East West Press.
2. J. Martin, Introduction to Languages and the Theory of Computation, McGraw-Hill Education.
3. P. Linz, An introduction to formal languages and automata, Narosa Publishers.

Course Code:	CSPC 200	**Pre-Requisites:**	NIL
Course Title:	Operating System	**L-T-P-C**	3-0-2-4

Course Outcomes:

CO1	Understand the functions, structures, evolution, and design of operating systems, including process scheduling and inter-process communication.
CO2	Analyze and apply process synchronization techniques, deadlock handling methods, and CPU scheduling strategies.
CO3	Implement and evaluate memory management schemes, including paging, segmentation, demand paging, and page replacement algorithms.
CO4	Explore file system management, protection and security mechanisms, virtualization, and access control techniques in operating systems.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	3	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit-I: Computer system architecture and organization, Introduction and evolution of OS, Introduction to distributed OS, Real-time systems, and multimedia systems. OS structures: OS services, system calls and programs, OS design and implementation. Processes: Process concept, scheduling policies, algorithms, multilevel queuing, operations on process, Inter-process communication. Threads: multithreading models and threading issues. CPU scheduling: Criteria and algorithms, multiprocessor, and thread scheduling.

Unit II: Process synchronization: critical sections, classical two-process, and n-process solutions, hardware primitives for synchronization, semaphores, monitors, and classical problems in synchronization (producer-consumer, readers-writer, dining philosophers, etc.).

Deadlocks: modeling, resource allocation, characterization, prevention and avoidance, detection and recovery.

Unit III: Memory management: Swapping, contiguous memory allocation, paging, multilevel paging, segmentation, demand paging, page replacement algorithms, allocation of frames, thrashing, working set model. Input/Output: I/O system and services, device controllers and device drivers, disks, scheduling algorithms, and management.

Unit IV: File system interface: access methods, access control, directory structures, file organization, file sharing, and protection. system performance, protection and security, OS design considerations for security, access control lists and OS support, internet, and general network security. The operating system as a service provider: Access control matrix, access control list, capability matrix, encryption, and access permissions in Linux and Windows.

Text / Reference Books:

1. A. Silberschatz, Peter B. Galvin, and G. Gagne, "Operating System Concepts," (9th or newer edition), Wiley.
2. H. Brinch, "Operating System Principles," Prentice Hall of India.
3. Dhamdhere, "Systems programming & Operating systems," TataMcGrawHil
4. A. N. Habermann, "Introduction to Operating System Design," Galgotia publication, New Delhi.
5. A.S. Tanenbaum, "Modern Operating Systems," Prentice Hall of India.

Course Code:	CSPC 204	Pre-Requisites:	CSPC 201
Course Title:	Artificial Intelligence and Soft Computing	L-T-P-C	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand and analyze problem-solving strategies in artificial intelligence, including search techniques and constraint satisfaction.
CO2	Apply evolutionary computing techniques such as genetic algorithms, genetic programming, and evolutionary programming for optimization problems.
CO3	Explore and implement biologically inspired algorithms, including swarm intelligence techniques like ant colony optimization and particle swarm optimization.
CO4	Develop an understanding of fuzzy logic concepts, including fuzzy sets, fuzzy inference systems, and fuzzification-defuzzification methods for decision-making applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit-1 (Introduction)
Introduction of Soft Computing, Soft Computing vs. Hard Computing, Various Types of Soft Computing Techniques, Applications of Soft Computing.

Unit-2 (AI Problem solving)
Uninformed Search Strategies, Informed Search Strategies, Local Search Strategies, Adversarial Search, Search for Constraint Satisfaction Problems.

Unit-3 (Knowledge and Reasoning)
Logical Agents, First-Order Logic Inference in First-Order Logic, Knowledge Representation, Automated Planning.

Unit-4 (Nature inspired algorithms)
Genetic Algorithms, Genetic Programming, Evolutionary Programming, Swarm Intelligence: Ant Colony Optimization, Artificial Bee colony, Particle Swarm Optimization.

Unit-5 (Fuzzy logic)
Fuzzy Sets, Fuzzy rules, Fuzzy Reasoning, Fuzzification and Defuzzification Methods, Fuzzy inference system.

Text Books:

1. Stuart J. Russell and Peter Norvig, Artificial Intelligence A Modern Approach, Prentice Hall, Fourth Edition, 2022.
2. Zbigniew Michalewicz, Genetic Algorithm+ Data Structures = Evolutionary Programs, Springer, Third Edition.
3. James Kennedy, Russell C. Eberhart and Yuhui Shi, Swarm Intelligence, Morgan Kaufmann, First Edition.
4. Jang J.S.R., Sun C.T. and Mizutani E , Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Pearson Education India, First Edition.

Reference Books:

1. D.E. Goldberg, Genetic Algorithms: Search, Optimization and Machine Learning, Addison Wesley, N.Y.
2. Marco Dorigo and Thomas Stützle, Ant Colony Optimization, The MIT Press, First Edition.
3. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill, Third Edition.

Course Code:	CSPC 206	**Pre-Requisites:**	NIL
Course Title:	Database Management Systems	**L-T-P-C**	3-0-2-4

Course Objectives:
At the end of the course, the student will be able to

CO1	Understand and analyze database fundamentals, data models, relational algebra, and query languages to design structured databases.
CO2	Apply normalization techniques and functional dependencies to optimize database design and ensure data integrity.
CO3	Demonstrate knowledge of transaction management, concurrency control, and ACID properties to ensure reliable database operations.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	3	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	3	3	3	1	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit-1 (Introduction)
Data, Database, Database management system, Historical background from file systems to Database Systems, Data Models, Relational Data Model, ER model, Schemas and Instances, Database users, DBMS architecture.
Unit-2 (Relational Model and Query Language)
Theory of Relational Database, Key Integrity constraint, Relational Algebra, Relational Calculus: Domain Relational Calculus, Tuple Relational Calculus, SQL, queries writing in SQL.
Unit-3 (Database Design)
Normalization, Database Anomalies, Functional Dependencies, Candidate and Super Key, Non-loss Decomposition, Dependency Preservation, First, Second, Third Normal, BCNF, etc.
Unit-4 (Transaction Processing)
Transaction concept, a simple transaction model, states, ACID Properties, implementation of ACID properties, Serializability.
Unit-5 (Concurrency Control)
Need for Concurrency, Lock-based protocols, Deadlock, Starvation, deadlock handling, time-stamp based protocols, validation-based protocols.
Text Books:

1. A Silberschatz, H.F. Korth & S. Sudarshan: Data Base System Concepts, Mc Graw Hill, 4th, 5th or 6th edition.
2. Elmasri &Navathe : Fundamentals of Database Systems, 5th, 6th, or 7th edition Pearson.

SEMESTER V

Course Code:	MAPC 301	**Pre-Requisites:**	MAPC 205
Course Title:	Operations Research	**L-T-P-C**	3-0-0-3

Course Objectives:

At the end of the course, the student will be able to

CO1	Solve Linear Programming Problem (LPP) using Simplex, Big-M and Two phase methods
CO2	Formulate Mathematical model and finding optimal solution of Transportation problem.
CO3	Determine the characteristics of a Queueing model
CO4	Determine the EOQ of an inventory model

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit-1 (Introduction)

Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems

Unit-2 (Transportation Problem)

Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions. Degenracy in Transportation problems.

Unit 3 (Queueing Theory)

Poisson process and exponential distribution. Poisson queues - Model (M/M/1):(□/FIFO), Model (M/M/1):(N/FIFO) and their characteristics.

Unit 4 (Elements of Inventory Control)

Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

Text Books:

1.H. A.Taha , Operations Research: An Introduction, PHI, Delhi, 2014
2.F.S. Hillier and G.J. Libermann, Introduction to Operations Re- search, McGraw Hill.
3. K. Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons.
4. V. Chvatal, Linear Programming, W.H. Freeman publishers.

Reference books:

1. S.D. Sharma, Operation Research, Kedar Nath & Co.
2. S.M. Sinha, Mathematical Programming; Theory and Methods, Elsevier Publications.
3. G. Hadley, Linear programming, Narosa Publishing House.

Course Code:	MAPC 303	**Pre-Requisites:**	MAPC 204
Course Title:	Scientific Computing	**L-T-P-C**	3-0-2-4

Course Objectives:
At the end of the course, the student will be able to

CO1	Apply numerical methods to solve initial and boundary value problems, both linear and nonlinear.
CO2	Analyze stability, consistency, and convergence of numerical methods for PDEs.
CO3	Solve parabolic, hyperbolic, and elliptic PDEs using appropriate numerical techniques.
CO4	Evaluate and optimize the accuracy and efficiency of numerical methods for solving PDEs.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO2	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:
Unit-1 (Ordinary Differential Equations)
Multistep (explicit and implicit) methods for initial value problems, Linear and nonlinear boundary value problems, Quasi-linearization and Shooting methods.

Finite difference approximations for derivatives, Boundary value problems with explicit and implicit boundary conditions, Error analysis, Stability analysis, Convergence analysis.

Unit-2 (Parabolic Equations)

One-dimensional parabolic equations, Explicit and implicit finite difference scheme, Consistency, stability and convergence. Lax equivalence theorem, ADI methods

Unit-3 (Hyperbolic Equations)

First-order quasi-linear equations and characteristics, Explicit methods, Implicit methods in One space dimension, Lax-Wendroff explicit method.

Unit-4 (Elliptic equations)

Solution of Laplace and Poisson equations in a rectangular region, Finite difference in Polar Coordinate Formulas for derivatives near a curved boundary when using a square mesh - discretization error, Mixed Boundary value problems, **Practicals:**

Students can use the PYTHON programming language for constructing:

1) Multi-step methods for solving IVP.
2) Shooting method for solving second order differential equation
3) FDM for second order linear nonlinear BVP with both Dirichlet boundary conditions
4) FDM for second order linear nonlinear BVP with both Neumann boundary conditions
5) An Explicit and Crank- Nicolson FDM for one-dimensional heat conduction problem
6) An Explicit and Implicit FDM for one-dimensional wave equation
7) An Explicit FDM for one dimensional Laplace equation An Explicit FDM for one dimensional Poisson equation

Text Books:

1. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd eds, AMS 2002.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2016.
3. G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press, 2004.

Reference books:

1) G. Evans, J. Blackledge, P. Yardley, Numerical Methods for Partial Differential Equations, Springer Science Business Media, 2012.
2) K. W. Morton, D. F. Mayers, Numerical Solution of Partial Differential Equations: An Introduction, Cambridge University Press, 2005.

Course Code:	CSPC 304	**Pre-Requisites:**	
Course Title:	Distributed Computing	**L-T-P-C**	3-0-0-3

Course Outcomes:

CO1	Able to apply knowledge of operating systems and networks to distributed systems
CO2	Design distributed algorithms for complex computing problems
CO3	Analyze the performance of algorithms and evaluate the scalability of solutions
CO4	Adapt existing centralized algorithms to distributed set up
CO5	Simulate the algorithms in distributed environment

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	3	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3
CO5	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1
Fundamental issues in Distributed Systems, Models of Distributed Computations, Handling time through clocks, Physical Time and Hardware Clock Synchronization, Logical Time and Software Clocks, Message Ordering Protocols, Interprocess Communication, Shared Memory Vs Message Passing Models, Distributed and Localized Algorithms, Evaluation of Correctness and Performance.
Unit 2
Protocols for Routing and Designing Virtual Constructs, MST, MIS, and CDS, Distributed Mutual Exclusion, Leader Election,
Unit 3
Distributed Deadlock Detection, Termination Detection, Global State Computation and Snapshot Recording.
Unit 4
Global Predicate Detection, Fault-Tolerance Issues, Basic Techniques for handling Crash Failure in Distributed Systems, Checkpointing and Rollback Recovery, Z-path and Z-cycles, Other Types of Failures in Distributed Computing Systems, Consensus and Agreement Protocols, FLP impossibility, Byzantine Generals Problem, Failure Detectors, Wait Freedom, Self-Stabilization, Peer-to-Peer Computing, Overlay Structures, Distributed Scheduling and Load Balancing, Naming, Security.

Text Books:
1. A D Kshemkalyani and MukeshSinghal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press 2008.
2. G Colouris, J Dollimore, and T Kindberg, Distributed Systems: Concepts and Design, 3/e Pearson Ed. 2002.
3. A S Tanenbaum and M van Steen, Distributed Systems: Principles and Paradigms, 3/e Pearson Ed. 2002.
4. V K Garg, Principles of Distributed Systems, Kluwer Academic Publishers, 1996.
5. Sukumar Ghosh, Distributed Systems: An Algorithmic Approach, 2/e Chapman& Hall.
6. V K Garg, Principles of Distributed Computing, IEEE Press.
7. Nancy Lynch, Distributed Algorithms, Morgan Kaufmann Press.

Course Code:	CSPC ***	**Pre-Requisites:**	
Course Title:	Data Mining and Data Warehousing	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Choose an appropriate data pre-processing techniques based on the given data.
CO2	Identify and design an appropriate data mining analysis technique given a problem.
CO3	Gain practical hands-on experience in implementing data mining algorithms

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3

Syllabus:
Unit-1 (Data Mining and Data Pre-processing)

Introduction to Data Mining, Motivation behind Data Mining, Data Mining Tasks, Issues in Data Mining Applications. Types of data, Data Quality, Data pre-processing, Similarity and Dissimilarity, Outlier Analysis, Data lakes, Data Fabric.

Unit-2 (Clustering)

Introduction, Applications, K-Means Algorithm, Hierarchical Algorithms, Density based Algorithms, Fuzzy c-Mean Algorithm, Silhouette Coefficient, DB-Index.

Unit-3 (Association Rule Mining)

Introduction, Applications, Market-Basket Analysis, Frequent Itemsets, Apriori Algorithm, Alternative Methods, FP Growth algorithm.

Unit-4 (Dimension Reduction and Introduction to Analytics)

Feature Selection Techniques, Principal Component Analysis, Classification overview.

Unit-5 **(**Web Data Mining)

Social Network Analysis: Preliminaries and Properties, Homophily, Triadic Closure, Clustering Coefficient, Centrality, Community Detection in Graphs and Networks.

Unit -6

Data Warehousing and Business Analysis: - Data warehousing Components –Building a Data warehouse –Data Warehouse Architecture – DBMS Schemas for Decision Support – Data Extraction, Cleanup, and Transformation Tools –Metadata – reporting – Query tools and Applications – Online Analytical Processing (OLAP) – OLAP and Multidimensional Data Analysis.

Text Books:

1. Tan,Pang-Ning & others. “Introduction to Data Mining” Pearson Education, 2006.
2. Jiawei Han, Micheline Kamber and Jian Pei“Data Mining Concepts and Techniques”, Third Edition, Elsevier, 2011.

Reference Books:

1. Han J &Kamber M, “Data Mining: Concepts and Techniques,” Morgan Kaufmann Publishers, Second Edition, 2006

2. Christopher Bishop: “Pattern Recognition and Machine Learning”, Springer International Edition

3. Tom M. Mitchell: “Machine Learning”, The McGraw-Hill Companies, Inc. 5.

4. Charu C. Aggarwal “Outlier Analysis” Springer International Publishing (2017)

5. Christopher D.M., Prabhakar R. & Hinrich S. “Introduction to Information Retrieval” Cambridge UP Online edition, 2009

6. Alex Berson and Stephen J. Smith “Data Warehousing, Data Mining & OLAP”, Tata McGraw – Hill Edition, Tenth Reprint 2007.

Course Code:	Machine Learning	**Pre-Requisites:**	CSPC 204, MAIC 201(Discrete Mathematics)
Course Title:	CSIC 301	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand Fundamental Mathematical Concepts
CO2	Develop and Apply Regression Models
CO3	Analyze and Design Probabilistic Classifiers
CO4	Apply Discriminative and Non-Metric Learning Methods
CO5	Perform Clustering and Dimensionality Reduction

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO5	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3

Syllabus:

Syllabus:

Unit-1 (Introduction)

Basic definitions, types of learning, hypothesis space and inductive bias, probability distributions and hypothesis testing using statistical tests, data pre-processing.

Unit-2 (Regression Techniques and Analysis)

Supervised learning using regression, types of regression, linear regression: simple and multiple, logistic regression, overview of other types of regression; model diagnostics and analysis using residual and outlier, handling of multi-collinearity.

Unit-3 (Classification)

Supervised learning using classification, types of classification, linear models: regression & SVM; non-linear models: decision tree induction, attribute selection measures: information gain, gain ration, Ginni index; tree pruning and scalability; Naive Bayes classifier; kNN; classification model evaluation metrics; improving accuracy using ensemble, random forest, bagging, boosting.

Unit-4 (Clustering)

Basic Clustering concepts, Standard k-Means clustering, finding optimal number of clusters, Modifications to the k-Means; hierarchical clustering.

Unit-5 (Advances in Machine Learning)

Gradient descent algorithm, bias-variance, cross-validation, recommender systems: association rules, collaborative filtering, user of similarity, overview of use of neural networks for learning

Text Books or Reference Books:

1. J. Han, M. Kamber, J. Pei, Data Mining Concepts and Techniques, Latest Edition
2. M. Pradhan, U. Dinesh Kumar, Machine Learning using Python, Wiley India, Latest Edition.
3. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.
4. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.
5. Introduction to Machine Learning Edition 2, by Ethem Alpaydin.

SEMESTER VI

Course Code:	MAPC 302	**Pre-Requisites:**	Nil
Course Title:	Algebra and Computational number theory	**L-T-P-C**	3-1-0-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Solve the system of congruences
CO2	Test quadratic residuosity
CO3	Know the basic arithmetic of finite fields
CO4	Apply Lenstra-Lenstra-Lovasz (LLL) algorithm for factoring polynomials with integer coefficients.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO2	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO3	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO4	2	1	1	-	1	-	-	-	-	-	-	-	1	-	-	1

Syllabus:

Unit 1 (Algorithms for Integer Arithmetic)

Divisibility, gcd, prime number theorem, modular arithmetic, modular exponentiation, congruence, Chinese remainder theorem (CRT), Hensel lifting, orders and primitive roots, quadratic residues, modular square roots, continued fractions, and CFRAC method for integer factoring.

Unit 2 (Representation of Finite Fields)

Prime and extension fields, representation of extension fields, polynomial basis, finite field arithmetic, primitive elements, normal basis, optimal normal basis, irreducible polynomials.

Unit 3 (Algorithms for Polynomials)

Root-finding and factorization, Lenstra-Lenstra-Lovasz (LLL) algorithm, polynomials over finite fields.

Unit 4 (Elliptic Curves)

The elliptic curve group, elliptic curves over finite fields, pairing on elliptic curves, elliptic curve method for integer factoring.

Text Books:

1. Victor Shoup, A Computational Introduction to Number Theory and Algebra, Version 2, Cambridge University Press, 2008.
2. Abhijit Das, Computational number theory, CRC Press, 2015.
3. Neal Koblitz, Introduction to Elliptic Curves and Modular Form, Springer, Second Edition, 1984.

Reference Books:

1. I. Niven, H. S. Zuckerman and H. L. Montgomery, An Introduction to the Theory of Numbers, Fifth Edition, John Wiley & Sons, 1991.
2. Kenneth H. Rosen, Elementary Number Theory & Its Applications, Sixth Edition, Pearson, 2011.
3. Joseph H. Silverman, The Arithmetic of Elliptic Curves, Second Edition, Springer, 2009.

Course Code:	MAPC 304	**Pre-Requisites:**	MAPC 203
Course Title:	Graph Theory	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand basic graph concepts and identify Eulerian and Hamiltonian circuits.
CO2	Apply graph algorithms to find the shortest paths and spanning trees.
CO3	Analyze matchings, connectivity, and network flows in graphs.
CO4	Evaluate graph coloring and planarity using key theorems.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Preliminary Concepts: Graph definition, various kinds of graphs; Incidence matrix; Isomorphism; Decomposition; Special graphs; Paths, cycles, and trails - connection in graphs, bipartite graphs, Eulerian Circuits; Vertex degree and counting, Hamiltonian Cycles - necessary and sufficient conditions; Review of digraphs.

Trees: Trees and distance - properties; Spanning trees; Kruskal and Prim algorithms with proofs of correctness; Shortest paths - Dijkstra's algorithm, BFS and DFS algorithms, Application to Chinese postman problem; Trees in Computer science - rooted trees, binary trees, Huffman's Algorithm.

Matchings: Matching in a graph and maximum matchings; Hall's matching theorem; Maximum bipartite matching - Augmenting path algorithm;

Connectivity: Connectivity; Characterizing 2-connected graphs; Menger's theorem; Network flow problems-Ford-Fulkerson labeling algorithm, Max-flow Min-cut Theorem.

Coloring: Chromatic number; Greedy coloring algorithm; Brooks' theorem; Graphs with large chromatic number; Turan's theorem.

Planar Graphs: Planar graphs; Euler's formula, dual of a plane graph; Kuratowski's Theorem; Five Color Theorem; Four Colour Problem.

Textbooks and References:

1. B. Douglas. Introduction to Graph Theory, West, Pearson, 2015, Second Edition.
2. R. Diestel, Graph Theory, Springer, 2017, Fifth Edition.
3. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, PrenticeHall, 1979.
4. J. A. Bondy and U. S. R. Murty, Graph Theory, Springer, 2008.

Course Code:	CSPC 302	**Pre-Requisites:**	
Course Title:	Big Data Analytics	**L-T-P-C**	3-0-2-4

Course Outcomes:

CO1	To analyze the attributes and associated issues of big data as well as will be able to propose solution for them.
CO2	To design efficient algorithms for mining different patterns from data streams.
CO3	To develop big data processing pipelines using different big data technologies.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	3	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1 (Introduction To Big Data)

Why Big Data? , The Four Dimensions of Big Data: Volume, Velocity, Variety, Veracity, Drivers for Big Data, Data Streams: Data Stream Models, Basic Streaming Methods, Data Synopsis, Sampling, Histograms, Wavelets

Unit 2 (Clustering and Frequent Pattern Mining from Data Streams)

Basic Concepts, Leader Algorithm, Clustering Algorithms, Search Space, Landmark Windows, Mining Recent Frequent Item Sets

Unit 3 (Classification from Data Streams)

Decision Trees, VFDT- Base Algorithm, Extensions to Basic Algorithm, Exhaustive Search, Functional Tree Leaves, Detecting Changes

Unit 4 (Big Data Enabling Technologies)

Hadoop Stack, Hadoop Distributed File System, Hadoop MapReduce, Introduction To Spark, Spark Streaming And Sliding Window Analytics, CAP Theorem, KeyValue Storage Model (Amazon's Dynamo), Document Storage Model (Facebook's Cassandra)

Text Books:

1. Baesens, Bart. Analytics in a big data world: The essential guide to data science and its applications. John Wiley & Sons, 2014.

2. Gama, Joao. Knowledge discovery from data streams. CRC Press, 2010.

3. Aggarwal, Charu C., ed. Data streams: models and algorithms. Vol. 31. New York: Springer, 2007.

4. Dirk Deroos et al., Hadoop for Dummies, Dreamtech Press, 2014.

5. Lam, Chuck. Hadoop in action. Simon and Schuster, 2010.

Reference Books:

1. Rutkowski, Leszek, Maciej Jaworski, and Piotr Duda. Stream data mining: algorithms and their probabilistic properties. Springer International Publishing, 2020.

2. Leskovec, Jure, Anand Rajaraman, and Jeffrey David Ullman. Mining of massive data sets. Cambridge university press, 2020.

Program Electives (Mathematics)

Course Code:	MAPE 301	**Pre-Requisites:**	Nil
Course Title:	Fluid Dynamics	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the concept of fluid and their classification, models and approaches to study the fluid flow
CO2	Formulate mass and momentum conservation principle and obtain solution for nonviscous flow
CO3	Know potential theorems, minimum energy theorem and circulation theorem
CO4	Understand three dimensional motions, Weiss's and Butler's sphere theorems and Kelvin's inversion theorem
CO5	Understand the concept of stress and strain in viscous flow and to derive Navier's Stokes equation of motion and solve some exactly solvable problems

Syllabus:

Unit 1

Classification of fluids, Continuum model, Eulerian and Lagrangian approach of description, Differentiation following the fluid motion, Irrotational flow, Vorticity vector, Equipotential surfaces, Streamlines, pathlines and streak lines of particles, Stream tube and stream surface, Mass flux density, Conservation of mass leading to the equation of continuity (Euler's form), Boundary surface, Conservation of momentum and its mathematical formulation (Euler's form), Integration of Euler's equation under different conditions, Bernoulli's equation, steady motion under conservative body forces.

Unit 2

Theory of irrotational motion, Kelvin's minimum energy and circulation theorems, Potential theorems, Two-dimensional flows of irrotational, incompressible fluids, Complex potential, Sources, sinks, doublets, and vortices, Milne Thomson circle theorem, Images with respect to a plane and circles, Blasius theorem.

Unit 3

Three-dimensional flows, Sources, sinks, doublets, Axi-symmetric flow and Stokes stream function, Butler sphere theorem, Kelvin's inversion theorem, Weiss's sphere theorem, Images with respect to a plane and sphere, Axi-symmetric flows and stream function, Motion of cylinders and spheres.

Unit 4

Viscous flow, stress and strain analysis, Stokes hypothesis, Navier - Stokes equations of motion, Some exactly solvable problems in viscous flows, Steady flow between parallel plates, Poiseuille flow, Steady flow between concentric rotating cylinders.

Text Books:

1) F. Chorlton, Text Book of Fluid Dynamics, CBS Publisher, 2005.
2) R.W. Fox, P.J. Pritchard and A.T. McDonald, Introduction to Fluid Mechanics, Seventh Edition, John Wiley& Sons, 2009.

Reference Books:

1. P.K. Kundu, I.M. Cohen, D.R. Dowling, Fluid Mechanics, Sixth Edition, Academic Press, 2016.

Course Code:	MAPE 302	**Pre-Requisites:**	MAPE 201
Course Title:	Computational Fluid Dynamics	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Know the basic conservation principles of mass, momentum and energy and their governing equations
CO2	Understand the basic aspects of discretization and numerical solutions using both finite difference and finite volume methods
CO3	Know some popular algorithms like SIMPLE and SIMPLER used to obtain the solutions of steady and unsteady flow problems by finite volume methods

Syllabus:

Unit 1

Basics of discretization using finite differences, Single and multi-step schemes for parabolic and hyperbolic PDEs, Finite difference schemes for convection-diffusion equation, Accuracy, Consistency, Stability and Convergence of a finite difference scheme, Courant Friedrich Lewy condition, Von Neumann and matrix stability analysis of finite difference schemes, Methods for solving discretized equations.

Unit 2

Mathematical description of physical phenomena, Finite volume method for diffusion and convection-diffusion equations, Discretization of one and two-dimensional steady-state diffusion and convection-diffusion equations, Central difference, upwind, exponential, hybrid, power-law and QUICK schemes, and their properties.

Unit 3

Flow field calculation, pressure-velocity coupling, vorticity-stream function approach, primitive variables, staggered grid, pressure and velocity corrections, pressure correction equation, SIMPLE, SIMPLER, and PISO algorithms.

Unit 4

Finite volume methods for unsteady flows, Discretization of one-dimensional transient heat conduction, explicit, fully implicit and Crank - Nicolson schemes, Implementation of boundary conditions.

Text Books:

1) R.H. Pletcher, J.C. Tannehill and D.A. Anderson, Computational Fluid Mechanics and Heat Transfer, CRC Press, Taylor and Francis, 2013.
2) J.D. Anderson, Computational Fluid Dynamics, McGraw-Hill, 1995.
3) S.V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, Taylor and Francis, Indian Edition, 2017.

Reference Books:

1. J.C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, Second Edition, SIAM, 2004.
2. J.W. Thomas, Numerical Partial Differential Equations: Finite Difference Methods, Springer, 2013.
3. H.K. Versteeg, and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Second Edition, Pearson, 2008.

Course Code:	MAPE 303	**Pre-Requisites:**	Nil
Course Title:	Mathematics of Data Science	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Analyze the basics of data science
CO2	Apply PCA
CO3	Analyze spectral clustering
CO4	Compute dimension reduction and clustering of random graphs
CO5	Apply approximation algorithms

Syllabus:

Unit 1 (Introduction and Algebra)

Introduction of Data Science, Visualization of data, Resampling, Distributions, Linear Model & Bayesian Model, Simple examples, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation, and Automatic Differentiation.

Unit 2 (Statistics)

Parameter Estimation, Bayesian Linear Regression, Maximum Likelihood as Orthogonal Projection, Principal Component Analysis (PCA), Spectral Clustering, Cheeger's inequality, Concentration of measure and tail bounds in probability. Dimension reduction through Johnson-Lindelstrauss Lemma and Gordon's Escape through a Mesh Theorem.

Unit 3 (Graph Theory) Approximation algorithms in Theoretical Computer science and the Max-cut problem, Clustering of random graphs, Stochastic Block model, Synchronization, Inverse problems on graphs.

Unit 4 (Optimization)

Continuous Optimization, Basics of duality in Optimization, Convex Optimization.

Text Books:

1. Joel Grus, Data science from scratch, O'Reilly Media, 2015.
2. Murtaza Haider, Getting started with data science, IBM Press, 2016.

Reference Books:

1. Lillian Pierson, Data science for Dummies, Wiley, Second Edition, 2017.
2. J Koponen, J Hidden, Data Visualization Handbook, CRC Press, 2019.
3. A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Marc Peter Deisenroth, Cambridge University Press, 2019.

Course Code:	MAPE 305	**Pre-Requisites:**	Nil
Course Title:	Numerical Linear Algebra	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the principles of SVD of matrices
CO2	Find QR factorization of a matrix using Householder triangularization and study its applications
CO3	Understand the basic concepts of linear algebra related to stability, accuracy,etc
CO4	Describe the numerical procedure of eigenvalue problem

Syllabus:

Unit 1
Fundamentals; Matrix-vector multiplication, Orthogonal vectors and matrices Norms, Computer arithmetic, Singular Value Decomposition.
Unit 2
QR Factorization and Least Squares; Projectors, QR factorization, Gram-Schmidt orthogonalization, Householder triangularization, Least squares problems.
Unit 3
Conditioning and Stability; Conditioning and condition numbers; Stability; Systems of Equations; Gaussian elimination; Cholesky factorization.
Unit 4
Eigenvalues; Overview of eigenvalue algorithms, Reduction to Heisenberg or tridiagonal form, Rayleigh quotient, inverse iteration, QR Algorithm without and with shifts, Computing the SVD
Text Books:
1) Lloyd N. Trefethen and D. Bau, Numerical Linear Algebra, SIAM, 1997. ISBN 0-89871-361-7.
2) D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Ed, Brooks/Cole, 2002. ISBN 0- 534-38905-8.
Reference Books:
1. J.W. Demmel, Applied Numerical Linear Algebra.
2. G.H. Golub and C.F. Van Loan, Matrix Computations.

Course Code:	MAPE 307	**Pre-Requisites:**	Nil
Course Title:	Matrix Computation	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand fundamental concepts in matrix computations
CO2	Have an overview of various decomposition, sensitivity and round-off errors
CO3	Understand QR algorithm and many more

Syllabus:

Unit 1:

Floating point computations, IEEE floating point arithmetic, analysis of round off errors, Sensitivity analysis and condition numbers, Linear systems, Jacobi, Gauss-Seidel and successive over relaxation methods, LU decompositions.

Unit 2:

Gaussian elimination with partial pivoting, Banded systems, positive definite systems, Cholesky decomposition, sensitivity analysis, Gram-Schmidt orthonormal process, Householder transformation, QR factorization, stability of QR factorization.

Unit 3:

Solution of linear least squares problems, normal equations, singular value decomposition (SVD), Moore-Penrose inverse, Rank deficient least squares problems, Sensitivity analysis of least-squares problems, Sensitivity of eigenvalues and eigenvectors.

Unit 4:

Reduction to Hessenberg and tridiagonal forms; Power, inverse power and Rayleigh quotient iterations, Explicit and implicit QR algo- rithms for symmetric and non-symmetric matrices, Reduction to bidiagonal form, Sensitivity analysis of singular values and singular vectors, Krylov subspace methods, conjugate gradient method.

Text Books:

1. B.N. Datta, Numerical Linear Algebra and applications, 2nd edition, SIAM, 1995.
2. G. H. Golub and C. F. Van Loan, Matrix Computations, 3rd edition, John Hopkins University. Press.

Reference Books:

1.L.N. Trefethen, Numerical Linear Algebra, SIAM 1997.

Course Code:	MAPE 309	**Pre-Requisites:**	Nil
Course Title:	Mathematical Modelling and Stimulation	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Use ordinary differential equations for mathematical modelling
CO2	Use difference equations and discrete dynamical systems
CO3	Use the Monte Carlo methods and its applications

Syllabus:

Unit 1:

History of Mathematical Modeling, latest development in Mathe- matical Modeling, Merits and Demerits of Mathematical Modeling, Quantitative and Qualitative approach of modeling, Conceptual and Physical models, stationary and in stationary models, distributed and lumped models, models in real world problem.

Unit 2:

Introduction to difference equations, Non-linear Difference equations, Steady state solution and linear stability analysis. Discrete dynamical systems, equilibrium and long term behavior, Linear Models, Growth models, Decay models, Drug Delivery Problem, Linear Prey- Predator models, Volterra's principle, Lanchester combat model.

Unit 3:

Introduction to Continuous Models, Drug Distribution in the Body, Epidemic Models (SI, SIR, SIRS, SIS, SEIR), Steady State solutions, Linearization and Local Stability Analysis, logistic, prey- predator model, Competition models.

Unit 4:

Spline, Random numbers, Generating discrete and continuous ran- dom variables, Multiple Regression, Variance reduction techniques, Statistical validation techniques, Markov chain, Monte Carlo meth- ods and applications.

Text Books:

1. Albright, Mathematical Modeling with Excel, Jones and Bartlett Publishers, 2010.
2. J. N. Kapur, Mathematical Modeling, New Age International, 2005.

Reference Books:

1. F. R. Marotto, Introduction to Mathematical Modeling using Discrete Dynamical Systems, Thomson Brooks/Cole, 2006.
2. Kai Velten, Mathematical modelling and simulation: introduc- tion for scientist and engineers, Willy, 2008.

Course Code:	MAPE 311	**Pre-Requisites:**	MAPC 204
Course Title:	Game Theory and Applications	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Identify strategic situations and represent them as games
CO2	Solve simple games using various techniques
CO3	Analyse economic situations using game theoretic techniques

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	2	-	-	-	-	2	-	3	3	3	-	2
CO2	3	3	3	3	3	-	-	-	-	2	2	3	3	3	3	3
CO3	3	3	2	3	3	-	-	-	-	2	2	3	3	3	3	3
CO4	3	3	3	3	3	-	2	-	-	2	2	3	3	3	3	3

Syllabus:

Unit 1 (Two Person Zero Sum Games)

The nature of games, Matrix Games, Dominance and Saddle point, Mixed strategies, Game trees, Application to business – Competitive decision making,
utility theory, Games against nature.

Unit 2 (Two Person Zero Sum Games and Applications)

Nash equilibrium and Non-cooperative solutions, the Prisoner's Dilemma, Application to Social Psychology – trust, suspicion, and the F-scale.

Unit 3(Strategic Moves and N-Person Games)

Basic of Strategic moves, Application to Biology – evolutionarily stable strategies, the Nash arbitration scheme and cooperative solutions, Application to Business – Management-Labor arbitration. Introduction to N-Person games, Application to Politics – Strategic voting, N-Person's Dilemma, Application to Athletics – Prisoner's Dilemma and the Football Draft.

Unit 4(Imputations, Dominance and Stable Sets)

Application to Anthropology – Pathan organization, the core, the shapely value, Application to Politics – the shapley-shubik power index.

Text Books:

1. P. D. Straffin, Game Theory and Strategy, Mathematical Association of America.
2. E.N. Barron, Game Theory; An introduction, John Wiley & Sons, 2008.

Reference Books:

1. R.A. Gibbons, Primer in Game Theory, Pearson Education, 1992.
2. W. F. Lucas, Game theory and its applications Mathematical Association of America.

Course Code:	MAPE 304	**Pre-Requisites:**	MAPC 303
Course Title:	Finite Element Theory and Algorithm	**L-T-P-C**	3-0-0-3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Determine an extremum by calculus of variations approach
CO2	Formulate a variational problem for a boundary value problem
CO3	Find the solution of one-dimensional problems
CO4	Find the solution of two-dimensional problems by rectangular elements
CO5	Find the solution of two-dimensional problems by triangular elements

Syllabus:

Unit 1 (Calculus of Variations)

Introduction, Euler's Equation, Euler Lagrange Equations, Ostrogradsky equation.

Unit 2 (Variational Formulation)

Variational Formulation for a boundary value problem with homogeneous and non-homogeneous boundary conditions, Rayleigh- Ritz minimization, Weighted residuals - Collocation, Least squares method, Galerkin, Petrov-Galerkin methods for boundary value problems.

Unit 3 (One Dimensional Problem)

Solution of one-dimensional boundary value problems by linear, quadratic and cubic shape functions.

Unit 4 (Two Dimensional Problems)

Solution of two-dimensional bound- ary value problems by linear, quadratic and cubic rectangular, serendipity and triangular shape functions. Time Dependent Problems: One-dimensional heat and wave equations.

Text Books:

1. J. N. Reddy, An introduction to the Finite Element Method, McGraw Hill, 4th Edition, 2020
2. I. J. Chung, Finite Element Analysis in Fluid Dynamics, McGraw- Hill International Book Company, Digitized Version, 2007.

Reference Books:

1. O. C. Zienkiewiez and K. Morgan, Finite Elements and Approx- imation, John Wiley, 1983.
2. P. E. Lewis and J. P. Ward, The Finite Element Method – Prin- ciples and Applications, Addison Wesley, 1991.

Course Code:	MAPE 306	**Pre-Requisites:**	Nil
Course Title:	Finite Volume Method	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Discretize steady and unsteady convection-diffusion problem
CO2	Identify the properties of discretization schemes
CO3	Solve convective problems using upwind, QUICK and hybrid schemes
CO4	Solve the velocity and pressure coupling
CO5	Solve discretised equations using multigrid methods

Syllabus:

Unit 1 (Convection - Diffusion Problems and Discretization)
Steady 1D, 2D, and 3D convection and diffusion problems - Discretization schemes, Central differencing scheme, Upwind differencing scheme, Hybrid differencing scheme, Power-law scheme, Properties of discretization schemes, Conservativeness - Boundedness – Transportive- ness.

Unit 2 (Higher - Order Differencing Schemes)
Quadratic Upwind Differencing Scheme: the QUICK scheme, Stability problems of the QUICK scheme and remedies, Generalisation of upwind-biased discretization schemes, Total variation, and TVD schemes, Criteria for TVD schemes, Flux limiter functions, Implementation, and Evaluation of TVD schemes.

Unit 3 (Solution Algorithms for Pressure - Velocity Coupling)
The staggered grid - SIMPLER algorithm.

Unit 4 (Solution of Discretised Equations)
Application of the TDMA to 2D and 3D problems, Point- iterative methods, Jacobi iteration method, Gauss-Seidel iteration method, Relaxation methods, Multigrid techniques, Multigrid cycles, Grid generation for the multigrid method.

Text Books:

1. H. Versteeg and W. Malalasekera, An introduction to CFD: The Finite Volume Method. Pearson, Second Edition, 2007.
2. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2009.

Reference Books:

1. D.M. Causon, C.G. Mingham, & L. Own, Introductory Finite Volume Methods for Partial Differential Equations, Springer, 2009.

Course Code:	MAPE 208	**Pre-Requisites:**	Nil
Course Title:	Symbolic Computing	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Introduce the fundamental concepts of symbolic computing
CO2	Provide a foundation to use basic building blocks of Mathematica and Matlab
CO3	Learn to write Mathematica and Matlab Scripts.
CO4	Explore various applications of Matlab in Mathematics
CO5	Provide the basic knowledge to use Matlab for programming.

Syllabus:

Unit 1(Introduction to Mathematica)

Difference between Numeric computing and Symbolic computing, Parts of Mathematica, Basics of programming in Mathematica, Built-in functions and constants, Numeric calculation using Mathematica, Symbolic computing with Mathmematica.

Unit 2 (Built-in function for Matrices and Linear Algebra)

Solving equations, Calculus with Mathematica, Solving ordinary Differential equations with Mathematica. Graphics and built-in graphics functions, User defined functions, Conditionals and looping in Mathematica. Modules, Simple programs using Mathematica.

Unit 3

Introduction to MATLAB, Advantages and disadvantages of MATLAB, MATLAB environment, MATLAB basics, Programming in MATLAB, Built-in functions.

Unit 4 (Application to Linear Algebra)

Curve fitting and interpolation, numerical integration and solving Ordinary differential equations. Branching statements, loops and program design. User defined functions, Input and output functions, introduction to plotting, handling Graphics.

Text Books:

1. Paul R.Wellin, Mathematica, Wolfram Research Inc., 2005.
2. Cleve Moler, Numerical Computing with MATLAB, SIAM, 2004.

Reference Books:

1. E. G. RAJAN, Symbolic Computing: Signal and Image Processing.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Cryptography	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Have been introduced to the concept of secure communication and fundamentals of cryptography
CO2	Know classical ciphers such as Vigenere Cipher and Hill Cipher
CO3	Have insight into DES and AES
CO4	Be familiar with secure random bit generator and linear feedback shift register sequences
CO5	Know of RSA, attacks on RSA, Diffie - Hellman key exchange and ElGamal, public key crypto system

Syllabus:

Unit 1(Introduction)
Review on basic group theory and basic number theory, Historical ciphers and their cryptanalysis, Principles of modern cryptography, perfect secrecy and one-time pad.

Unit 2 (Private - key Cryptography)
Stream ciphers, Block ciphers - SPN, Feistel design, DES, AES. Introduction to differential and linear cryptanalysis.

Unit 3 (Public - key Cryptography)
RSA Cryptosystem, Primality testing, Algorithms for factoring, Diffie-Hellman key-exchange protocol, Discrete-Logarithm Problem (DLP), ElGamal Cryptosystem, Algorithms for DLP.

Unit 4 (Elliptic Curves)
Basic facts, elliptic-curve cryptosystem. Discussion on Hash functions, Digital signatures, and other cryptography topics.

Text Books:

1. J.A. Buchmann, Introduction to Cryptography, Second Edition, Springer 2003.
2. D.R. Stinson, Cryptography - Theory and Practice, CRC Press, Taylor & Francis, 2005.

Reference Books:

1. W. Trappe and L.C. Washington, Introduction to Cryptography: With Coding Theory, Pearson, 2006.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Applied Measure Theory	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Verify whether a given subset of R or a real-valued function is measurable
CO2	Demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems and their applications.
CO3	Know some popular algorithms like SIMPLE and SIMPLER used to obtain the solutions of steady and unsteady flow problems by finite volume methods
CO4	Extend the concept of outer measure in an abstract space and integration with respect to a measure
CO5	Know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations
CO6	Learn and apply Holder and Minkowski inequalities in Lp-spaces and understand ompleteness of Lp-spaces and convergence in measures

SYllabus:
Unit 1:
Lebesgue outer measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesgue measurability, Non-measurable sets.
Unit 2:
Integration of nonnegative functions, General integral, Integration of series, Riemann and Lebesgue integrals.
Unit 3:
Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and integration, Absolute continuity of functions, Measures and outer measures, Measure spaces, Integration with respect to a measure.
Unit 4:
The Lp - paces, Holder and Minkowski inequalities, Completeness of Lp - spaces, Convergence in measure, Almost uniform convergence, Egorov's theorem.

Text Books:
1. G. de Barra, Measure Theory and Integration, New Age International (P) Ltd., New Delhi, 2014.
2. Scheme and Syllabi 70 w.e.f. 2023 - 24
3. M. Capinski and P.E. Kopp, Measure, Integral and Probability, Springer, 2005.

Reference Books:
1. E. Hewitt and K. Stromberg, Real and Abstract Analysis: A Modern Treatment of the Theory of Functions of a Real Variable, Springer, Berlin, 1975.
2. H.L. Royden and P.M. Fitzpatrick, Real Analysis, Fourth Edition, Pearson, 2015.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Fuzzy Mathematics	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the relation between imprecise data and fuzzy sets
CO2	Deal with arithmetic operations of fuzzy numbers
CO3	Understand fuzzy rule-based implications and approximate reasoning
CO4	Distinguish between possibility and probability
CO5	Apply fuzzy tools to solve optimization problems

Course content:

Unit 1 (Fuzzy Sets and Uncertainty)

Basic concepts of fuzzy sets and fuzzy logic, Motivation, Fuzzy sets and their representations, Membership functions and their designing, Operations on fuzzy sets, conjunct fuzzy sets, Alpha-level cuts, and Geometric interpretation of fuzzy sets. Fuzzy extension principle and its application.

Unit 2 (Fuzzy Arithmetic)

Fuzzy numbers, Fuzzy numbers in the set of integers, Arithmetic operations on fuzzy numbers.
Fuzzy Relations: Linguistic variables, Linguistic modifiers, Fuzzy rules, Fuzzy relations, Basic properties of fuzzy relations, Composition of fuzzy relations.

Unit 3 (Fuzzy Reasoning)

Fuzzy mapping rules and fuzzy implication rules, Fuzzy rule-based models for function approximation. Possibility Theory: Fuzzy logic, Truth, Propositions of fuzzy logic, Fuzzy logic and probability theory, Possibility and Necessity, Possibility versus probability, Probability of a fuzzy event, Bayes' theorem for fuzzy events, Probabilistic interpretation of fuzzy sets.

Unit 4 (Fuzzy Optimization)

Decision-making in a Fuzzy environment, Fuzzy Multi-criteria decision-making, Fuzzy Linear programming.

Text Books:

1. H. J. Zimmermann, Fuzzy set theory and its applications, Springer Science & Business Media, Fourth Edition, 2011.
2. K. H. Lee, First course on fuzzy theory and applications, Springer Science & Business Media, First Edition, 2005.

Reference Books:

1. W. Pedrycz & F. Gomide, Fuzzy Systems Engineering: Toward Human-Centric Computing, Wiley – IEEE, First Edition, 2007.
2. T. J. Ross, Fuzzy logic with engineering applications, John Wi- ley & Sons, Fourth Edition, 2016.
3. G. J. Klir & B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice-Hall of India Pvt. Limited, First Edition (Reprint), 2008.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 205
Course Title:	Financial Mathematics	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Know the main features of models commonly applied in financial firms, be able to express these mathematically and be able to appraise their utility and effectiveness
CO2	Explain and critically appraise the rationale for the selection of mathematical tools used in the analysis of common financial problems
CO3	Demonstrate an ability to select and apply numerical methods appropriate for the solution of financial problems

Syllabus:
Unit 1 (Basics of Financial Markets)
Introduction and main theme of mathematical finance, financial markets and terminology, time value of money, interest rate, discount rate, bonds and bonds pricing, yield curves, duration and convexity, term structure of interest rates, spot and forward rates, net present value, net future value, financial instruments, underlying and derivative securities, types of derivatives, options, forwards, futures, swaps, concept of arbitrage.
Unit 2 (Portfolio Modeling and Analysis, Probability Essentials)
Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean-variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM).
Probability spaces, filtrations as information content, random variables, conditional expectations, Definition and classification of random processes, martingales.
Unit 3 (Discrete - Time Finance)
Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and the fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives.
Unit 4 (Continuous - Time Finance)
Black-Scholes-Merton model of stock prices as geometric Brownian motion, derivation of the Black-Scholes-Merton partial differential equation, the Black- Scholes formula and simple extensions of the model, self-financing strategies and model completeness, risk-neutral measures, the fundamental theorems of asset pricing, continuous time optimal stopping and pricing of American options, forwards and futures in Black-Scholes-Merton model, Brownian motion, martingales.
Text Books:
1. M. Capinski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer.
2. J. C. Hull, Options, Futures and Other Derivatives, Pearson Education.
3. S. Shreve, Stochastic Calculus for Finance, Springer.

Reference Books:

1. G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, Oxford University Press.
2. M. Capinski and P.E. Kopp, Measure, Integral and Probability, Springer.
3. R. J. Elliott and P. E. Kopp, Mathematics of Financial Markets, Springer.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Approximation Theory	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand approximation in normed linear spaces
CO2	Use the properties of Chebyshev polynomials in approximation problems
CO3	Find Generalized approximations
CO4	Approximate function by special functions
CO5	Apply the results in determining the best approximation

Syllabus:

Unit 1 (Linear Chebyshev Approximation)
Approximation in normed linear spaces Existence, uniqueness approximation of vector-valued functions, Haar subspaces, approximation of real-valued functions on an interval.
Unit 2 (Chebyshev Polynomials)
Properties- extremal properties of Chebyshev polynomials Strong Uniqueness and continuity of metric projection, discretization, discrete best Approximation.
Unit 3 (Interpolation)
Introduction - algebraic formulation of finite interpolation, Lagrange form, Extended Haar subspaces and Hermite interpolation, Hermite-Fejer interpolation.
Unit 4 (Best Approximation in Normed Linear Spaces)
Introduction - approximative properties of sets-characterization and duality. Projection: Continuity of metric projections, convexity, solarity and Chebyshevity of set's, best Simultaneous approximation.
Text Books:
1. Hrushikesh N. Mhaskar and Devidas V. Pai, Fundamentals of Approximation Theory, Narosa Publishing House, 2000.

Reference Books:

1. Ward Cheney and Will Light, A Course in Approximation Theory, American Mathematical Society, 2000.
2. E. W. Cheney, Introduction to Approximation Theory, AMS Chelsea Publication, 1966.
3. Ivan Singer, Best Approximation in Normed Linear Spaces by Elements of Linear Subspaces, Springer-Verlag, 1970.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Differential Geometry	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the concepts of graphs, level sets as solutions of smooth real valued functions vector fields and tangent space
CO2	Comfortably familiar with orientation, Gauss map, geodesic and parallel transport on oriented surfaces
CO3	Learn about linear self-adjoint Weingarten map and curvature of a plane curve with applications in geometry and physics
CO4	Know line integrals, be able to deal with differential forms and calculate arc length and curvature of surfaces
CO5	Deal with parametrization and be familiar with well-known surfaces as equations in multiple variables, able to find area and volumes
CO6	Study surfaces with boundary and be able to solve various problems and the Gauss-Bonnet theorem

Course content:
Unit 1
Graph and level sets, vector fields, tangent spaces.
Unit 2
Surfaces, orientation, the Gauss map, geodesics, parallel transport.
Unit 3
Weingarten map, curvature of plane curves, arc length and line integrals, curvature of surfaces.
Unit 4
Parametrized surfaces, surface area and volume, surface with boundary, the GaussBonnet theorem.
Text Books:
1. W. Ku ̇hnel, Differential Geometry, Curves-Surfaces-Manifolds, Third Edition, American Mathematical Society, 2013.
2. A. Mishchenko and A. Formentko, A Course of Differential Ge- ometry and Topology, Mir Publishers Moscow, 1988.

Reference Books:
1. Pressley, Elementary Differential Geometry, Springer, India, 2004.
2. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer, India, 2004.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Abstract Algebra	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Analyse the structure of Groups
CO2	Learn basic definition of ring and homomorphrism of rings
CO3	Distinguish the properties among rings structures
CO4	Learn important classes of rings like Euclidean Domains, Principal Ideal Domains, Unique Factorization Domains

Course content:

Unit 1 (Groups)
Introduction, Semi-groups, Groups, Subgroup, Generators and Evaluation of Powers, Cosets and Lagrange's Theorem, Permutation Groups, Normal Subgroups, Quotient groups.
Unit 2(Group Homomorphisms)
Automorphisms, Isomorphisms, Fundamental theorems of group homomorphisms, Cayley's Theorem, Group actions, Burnsides Theorem, Sylow's Theorems 1st, 2nd, 3rd and their applications.
Unit 3 (Rings)
Basic concepts in rings, ideals, homomorphism of rings, quotients with several examples.
Unit 4 (Integral Domain) Euclidean domains, principal ideal rings/domains, factorization domains, and unique factorization domains. Eisenstein's irreducibility criterion and Gauss's lemma.
Text Books:
1. 1. Dummit and Foote, Abstract Algebra, 3rd ed. Wiley, New York, 2003.
2. Scheme and Syllabi 81 w.e.f. 2023 - 24
3. I.N. Herstein, Topics in Algebra, 3rd ed. Wiley, New York, 1996.
4. Artin, Michael, Algebra, Prentice Hall, Inc., Englewood Cliffs, NJ, 1991.
5. C. Musili, Introduction to Rings and Modules, Narosa, 1992.

Reference Books:

1. P.R. Halmos, Nave Set Theory, Springer, New York, 1991.

2. Jacobson, Nathan, Basic Algebra, Volume 1, second edition, W.H. Freeman and Company, New York, 1985.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Optimization Techniques	**L-T-P-C:**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand optimization models and apply them to real life problems
CO2	Find solution to linear optimization problems
CO3	Determine solution to non-linear optimization problems
CO4	Understand the multistage problems and derive solutions
CO5	Apply search techniques to unconstrained optimization problems

Course content:
Unit 1 (Convex Optimization and Quadratic Programming)
Convex functions and their properties, convex optimization problems, con- vex programming problems, Quadratic programming problems, wolf method for quadratic programming.
Unit 2 (Some Generalized Convex Functions and Fractional Programming) Quasiconvex and Quasiconcave functions, Pseudocon- vex and Pseudoconcave functions, Linear fractional programming problems.
Unit 3 (Optimality Conditions and Duality in Nonlinear Programming)
Introduction, feasible directions and linearizing cone, Basic constraint qualification, lagrangian and lagrange multipliers, karush kuhn tucker necessary/sufficient optimality conditions, duality in nonlinear programming, wolf dual, mixed dual and Lagrange dual.
Unit 4(Algorithm in Nonlinear Programming)
Franck and wolf's method, Gradient projection method, Penalty function method, barrier function method, multistage decision problems.
Text Books:
1. C.R.Bector, S.Chandra, J. Dutta, Principles of Optimization Theory, Narosa Publications, 2016.
2. M.S. Bazaraa, H.D.Sherali, & C.M. Shetty, Nonlinear Program- ming Theory & Algorithms, John Willey & Sons, 2006.
Reference Books:

1. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical optimiza- tion with applications, Narosa Publications, 2009.
2. Singiresu S. Rao, Engineering Optimization: Theory and Prac- tice, John Wiley &Sons, 2009.
3. N.S. Kambo, Mathematical Programming Techniques, East-West Press Pvt. Ltd. 2008.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Algebraic coding theory	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Get an insight into matrix representation of a code as well as encoding and decoding
CO2	Understand Hamming codes, MDS codes and Reed Muller codes
CO3	Learn about cyclic codes and their generator polynomial

Course content:
Unit 1:
Introduction to algebraic coding theory, Linear codes, Hamming weight, Generator matrix, Parity check matrix, Equivalence of linear codes, Bounds on codes, Hamming codes, MDS codes, Propagation rules, Lengthening of code, Subcodes, Puncturing of code, Direct sum construction, Reed - Muller codes, Subfield codes.

Unit 2:
Cyclic codes, Cyclic codes as ideals, Generator polynomial of cyclic codes, Matrix representation of cyclic codes, Burst error correcting codes, Some special cyclic codes, BCH codes, Reed Solomon codes.
Text Books:
1. S. Ling and C. Xing, Coding Theory: A First Course, Cambridge University Press, 2004
2. R. Hill, A First Course in Coding Theory, Oxford University Press, 1986.

Reference Books:

1. W.C. Huffman and V. Pless, Fundamentals of Error Correcting Codes, Cambridge University Press, 2010.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 201 and MAPC 202
Course Title:	Functional analysis	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the nature of Banach spaces
CO2	Understand the nature of Hilbert spaces
CO3	Prove the open mapping theorem, closed graph theorem and uniform boundedness principle
CO4	Apply results of this course in solving operator equations

Course content:
Unit 1 (Banach Spaces)
Normed linear spaces, Banach spaces Definition and some examples, Incomplete normed linear spaces, Bounded linear operators, Hahn-Banach theorem.

Unit 2 (Dual spaces)
Conjugate (or dual) spaces, Natural imbedding of normed linear space N in its second conjugate N**, Open mapping theorem, Closed graph theorem, Conjugate of an operator, Uniform boundedness principle.

Unit 3 (Hilbert spaces)
Hilbert Spaces: Definition and basic properties, Orthogonal complements , Orthonormal sets, Bessel's in-equality, Riesz representation theorem.

Unit 4 (Dual of a Hilbert space)
The dual of a Hilbert space, Adjoint of an operator, Projections and Projection theorem.

Text Books:

1. George F. Simmons, Introduction to Topology andModern Analysis, McGraw Hill Inc., 2004.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 2007.
3. Balmohan V. Limaye, Functional Analysis, New Age International, Revised Third Edition, 2017.

Reference Books:

1. J. Conway, A Course in Functional Analysis, Springer, Second Edition, 2007.
2. Casper Goffman and George Pedrick, A First Course in Functional Analysis, AMS Chelsea Publishing, Second Edition, 1983.
3. Peter D. Lax, Functional Analysis, Wiley-Interscience, 2002.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 202
Course Title:	Topology	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Compare nature of spaces with different topologies
CO2	Understand connectedness and compactness in spaces with different topologies
CO3	Categorize spaces based on countability and separation axioms
CO4	Combine results in proving results such as Urysohn Lemma and Urysohn metrization theorem
CO5	Understand the notion of completeness with its importance in Baire's Category theorem

Course content:

Unit 1 (Topological Spaces and Continuous Functions)
Definition, Basis for a topology, Order topology, Product topology, Subspace topology, Closed sets, T1 axiom and Hausdorff spaces, Continuous functions, Homeomorphisms, Product and box topologies, Metric topology.
Unit 2 (Connectedness and Compactness in Topological Spaces)
Connected spaces, Components of a space, Com pact spaces.
Unit 3 (Countability and Separation Axioms)
Countability axioms, Separation axioms, Normal spaces, Urysohn Lemma, Urysohn Metrization theorem, Brief introduction to: Tietze Extension theorem, Tychonoff theorem, Stone-Cech Compactification.
Unit 4 (Completeness)
Complete metric spaces, Baire's Category theorem.
Text Books:
1. James R. Munkres, Topology, Prentice Hall of India, Second Edition, 2007.
2. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Inc., 2004.
Reference Books:
1. Fred H. Croom, Principles of Topology, Cengage Learn ing, 2008
2. John L. Kelley, General Topology, Springer, 1991.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 204
Course Title:	Spectral methods	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the basics of MATLAB
CO2	Understand the basics of spectral methods
CO3	Evaluate Fourier and Chebyshev spectral differentiation using differentiation matrices and FFT's
CO4	Solve IVP's and BVP's using spectral methods
CO5	Determine stability, convergence criterion and stiffness
CO6	Understand the mathematical concepts of spectral element methods

Course content:
Unit 1(Basics of Matlab)
Introduction to Matlab, Programming in Matlab, Branching and looping, Built-in functions, and user-defined functions.
Spectral Methods: Historical background, Introduction to spectral methods via orthogonal functions, some examples of spectral methods, Spectral differentiation versus Finite differences, MATLAB as a tool in problem solving, Basic layout of spectral methods.
Unit 2 (Fourier Spectral Differentiation)
Fourier approximation, Fourier spectral differentiation via differentiation matrices, Smoothness and accuracy, Aliasing and aliasing removal, MATLAB demonstrations.
Unit 3 (Chebyshev Spectral Differentiation)
Polynomial approximation, Jacobi polynomials, Chebyshev spectral differentiation via Differentiation matrices, Smoothness and accuracy, MATLAB demonstrations.
Unit 4 (Initial Value Problems and Boundary Value Problems) Spectral method treatment of problems with mixed initial/boundary conditions, Semi implicit methods, Case studies, and MATLAB demonstrations.
Spectral method treatment of problems Dirichlet/Neumann/Robin type boundary conditions, Eigen boundary value problems, Boundary value problems in Polar coordinates, Differential Eigen problems, Case studies, and MATLAB demonstrations.
Text Books:
1. Cleve Moler, Numerical Computing with MATLAB, SIAM, 2004.
2. L. N. Trefethen, Spectral Methods in Matlab, SIAM, 2000.
3. C. Canuto, M.Y. Hussaini, Spectral Methods: Fundamentals in Single Domain, A. Quarteroni and T. A. Zang, Springer Verlag, First Edition, 2006.

Reference Books:
1. D. Gottlieb and S. A. Orszag, Numerical Analysis of Spectral Methods: Theory and Applications, CBMS NSF 26, Philadelphia: SIAM, 1987.
2. C. Canuto, M.Y. Hussaini, A. Quarteroni and T.A. Zang, Spectral Methods in Fluid Dynamics, Springer Verlag Berlin Heidelberg, First Edition, 1988.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 205
Course Title:	Stochastic Processes and Queueing Theory	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Develop an understanding to the basic concepts of Random Processes, Expectations and
CO2	Able to understand and apply the Stochastic processes to Science and Engineering problems and applications.
CO3	Able to calculate the n-step transition probabilities for any Markov chain and understand about the birth and death of processes.
CO4	Able to apply Markov chain & Birth Death process to real life problems.
CO5	Develop an understanding of various Queuing Systems.

Course content:

Unit 1 (Introduction):

Random variables, Functions of random variables, joint1y distributed random variables. Expectation, Expectation of functions of more than one random variable, Covariance and Correlation, Auto and Cross Correlation, Correlation Co-efficient, Parameter Estimation – Maximum Likelihood Estimation and Maximum a Posteriori.

Unit 2 (Stochastic Processes)

Stochastic Processes, Classification of stochastic processes, Stationary Random Processes- First order, second order and nth order, Strict sense stationary process, Ergodic Process, the Bernoulli process, The Poisson process, Renewal process, Advanced Renewal Theory, Renewal Function, Alternating Renewal Processes.

Unit 3 (Markov Chains)

Markov Chains, Computation of n-step transition probabilities, Chapman-Kolmogorov theorem, Classification of states of a Markov Chain, Distribution of times between state changes, Irreducible finite chains with aperiodic states, Birth and Death processes, Pure Birth Process, Pure Death Process, Non-Birth-Death Processes, Analysis of program execution time.

Unit 4 (Queueing Theory)

Introduction to Queuing Theory, General Queuing, Components of a queuing system, Deterministic Queues, (M/M/1):(∞/FIFO)-Single server with infinite capacity, Extension to (M/M/2): (∞/FIFO), (M/M/k) : (∞/FIFO)- Multiple server with infinite capacity, Engset Loss Formula, M/G/1 queuing system, M/G/1 with non-FIFO disciplines, M/G/∞, Queues with time-varying arrival rate.

Text Books:

1. A. Populis and S.U. Pillai, "Probability, Random Variables, and Stochastic Process", 4th Edition, McGraw-Hill.
2. S. Palaniammal, "Probability and Queueing theory." Prentice Hall of India.
3. V. Sundarapandian, "Probability, Statistics and Queueing Theory." Prentice Hall of India.

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Numerical optimization	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the theory of optimization problems
CO2	Apply methods such as line search, steepest descent for solving optimization problems

Course content:

Unit 1:

Introduction to optimization problems, Convex sets and convex funcions, their properties, convex programming problems, Lagranges Multiplier mehtod, Optimality conditions for unconstrained minimization and constrained minimization problems, KKT conditions.

Unit 2:

Unimodal functions, Fibonnacci search, Linesearch methods, Convergence of generic line search methods, Method of steepest descent, more general descent methods, Conjugate gradient methods, Fletcher Reeves methods for nonlinear functions, Interior point methods for inequality constrained optimization, Merit functions for constrained minimization, logarithmic barrier function for inequality constraints, A basic barrier-function algorithm, perturbed optimality conditions, A practical primal-dual method

Unit 3:

Newton's method for first-order optimality, The Sequential Quadratic Programming iteration, Line search SQP methods, Trust-region SQP methods

Unit 4:

Mulitobjective programming, Efficient solutions, Dominated cones, Formulation of Goal programming problems and solution methodologies for linear Goal programming problem. Introduction to Evolutionary methods and global optimization.

Textbooks:

1. J. Nocedal and S. Wright, Numerical Optimization, Springer Verlag 1999

2. P. Gill, W. Murray and M. Wright, Practical Optimization, Academic Press 1981

3. R. Fletcher, Practical Methods of Optimization, 2nd edition Wiley 1987, (republished in paperback 2000)

4. A. Conn, N. Gould and Ph. Toint, Trust-Region Methods, SIAM 2000

Course Code:	MAPE	**Pre-Requisites:**	Nil
Course Title:	Stochastic Differential Equations	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand Ito Formula
CO2	Understand the existence and uniqueness of solutions of stochastic differential equations
CO3	Solve stochastic differential equations with applications

Course content:
Unit 1:

Introduction: Stochastic analogs of classical differential equations.
Mathematica; preliminaries: Probability space, random variable, stochastic process, Brownian motion.
Unit 2:

Ito Integral: Definition, Properties, extensions.
Ito formula and Martingale representation Theorem: One-dimensional Ito formula, Multi-dimensional Ito formula, Martingle representation Theorem.
Unit 3:

Stochastic differential equations: Examples and some solution methods, Existence an Uniqueness result, weak and strong solutions.

Applications: Boundary value problems, filtering, optimal stopping, stochastic control, mathematical finance.

Text Books:

1. B. K. Oksendal, Stochastic Differential Equations: An Introduction with Applications, 6th edition, Apringer, 2010.
2. I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calxulus, Springer, 1991.

Reference Books:

1. P. Protter, Stochastic Integration and Differential Equations, Springer, 2nd edition. 2010.
2. I. Karatzas and S.E. Shreve, Methods of Mathematical Finance, Springer, 2010.
3. S. Watanabe and N. Ikeda, Stochastic Differential Equations and Diffusion Processes, North-Holland, 1981.

Course Code:	MAPE	**Pre-Requisites:**	MAPC 205
Course Title:	Statistical Stimulation and Data Analytics	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand of statistical simulation techniques
CO2	Proficiency in programming languages and software
CO3	Practical experience in analyzing real-world datasets

Course Content:
Unit 1
Simulation of random variables from discrete, continuous, multivariate distributions and stochastic processes.
Unit 2
Computer Intensive Inference Methods - Jack-Knife, Bootstrap, cross validation, Monte-Carlo methods.
Unit 3
Regression analysis, scatter plot, residual analysis. Computer Intensive Inference Methods - Jack-Knife, Bootstrap, cross validation, Monte Carlo methods and permutation tests.
Unit 4
Graphical representation of multivariate data, Cluster analysis, Principal component analysis for dimension reduction, Dimension reduction using LASSO, E.M. Algorithm, Markov Chain Monte Carlo.

Text Books:
1.B. Efron and R.J. Tibshirani, An Introduction to the Bootstrap, (Chapman and Hall), 1994.
2.Anderson Sweeney Williams (2011). Statistics for Business and Economics. “Cengage Learning”.
3.Jay L. Devore (2011). Probability and Statistics for Engineering and the Sciences. “Cengage Learning”.
Reference Books:
1) B.S. Everitt, S. Landau, M. Leese, D. Stahl, Cluster Analysis, (Wiley), 2011.
2) G. M. McLachlan and T. Krishnan, The EM Algorithm and Extensions, (Wiley), 1997.

Program Electives (Computing)

Course Code:	CSTC 302	**Pre-Requisites:**	
Course Title:	Randomized Algorithm and Probabilistic Analysis	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Apply basic concepts of approximation, randomization and distributed computing in algorithmic context.
CO2	Designs randomized parallel algorithms, approximation and distributed algorithms that run fast or that return the correct output with high probability
CO3	Derives good upper bounds for the expected running time of advanced algorithms.
CO4	Can apply the probabilistic method to show the existence of certain combinatorial objects design and analyse.

Course Content:
Unit 1: (Introduction)

Models of computation, randomized polynomial identity testing algorithm (SchwartzZippel), Karger's randomized min-cut algorithm. Randomized Primality Testing, arkov's inequality, Chebyshev's inequality, moment generating functions and Chernoff bounds. Randomized routing.

Unit 2:

Moments and Deviations, Second-Moment Method, Numerical Probabilistic algorithms, Lovasz local lemma with applications, Poissonization technique, Power of two choices, Metric embeddings,

Unit 3:

Intro to Markov Chains, Mixing Times. Strong Stationary Times, and Coupling. Martingales, stopping times. The Martingale Stopping Theorem, and applications.

Unit 4:

Approximation Algorithms: Greedy Approximation Algorithms, Dynamic Programming and Weakly Polynomial-Time Algorithms, Linear Programming Relaxations, Randomized Rounding, Load balancing.

Text Books:

1.Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein. Third Edition. MIT Press and PHI, 2010.

2. Algorithm Design and Applications by Michael T. Goodrich and Roberto Tamassia, John wiley publication.

3. Randomized Algorithms by Rajeev Motwani, Prabhakar Raghavan, published by Cambridge University Press, 2014.

4. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, by Mitzenmacher and Upfal, Cambridge University Press, 2nd edition, 2017

5. The Design of Approximation Algorithms by David P. Williamson and David B. Shmoys, Cambridge University Press.

6. Algorithm Design by Jon Kleinberg, Eva Tardos by Pearson publications

Course Code:	CSTC 304	**Pre-Requisites:**	
Course Title:	High Performance Computing	**L-T-P-C**	3-0-2

Course Outcomes:

At the end of the course, the student will be able to

CO1	Evaluate the performance of parallel systems using speedup, efficiency, and scalability measures
CO2	Develop and implement parallel algorithms for sorting, matrix operations, and Fast Fourier Transforms (FFT).
CO3	Write and execute parallel programs using the Message Passing Interface (MPI) for efficient communication and data management.
CO4	Apply parallel computing techniques to solve complex problems using methods like Octrees, N-body simulations, and Bayesian network construction.

Course Content:

Unit 1:

Performance measures: Speedup, efficiency and scalability. Model of parallel computation and basic communication primitives. Parallel prefix and applications, Parallel sorting, Embeddings, Parallel matrix algorithms.

Unit 2:

Communication networks for parallel computers and parallel models of computation, Parallel fast Fourier transforms.

Unit 3:

Parallel Programming with MPI: Writing and executing MPI programs, collective communication, grouping data for communication, communicators and topologies.

Unit 4:

Parallel random number generation, Parallel Octrees, Parallel N-body methods, Parallel Bayesian network construction.

Text Books:

1. Introduction to Parallel Computing: Design and Analysis of Algorithms by A. Grama, A. Gupta, G. Karypis and V. Kumar.

2. Parallel Programming with MPI by Peter S. Pacheco.

3. Introduction to High Performance Scientific Computing Victor Eijkhout, Edmond Chow, Robert van de Geijn

Course Code:	CSTC 306	**Pre-Requisites:**	
Course Title:	Distributed Block Chain Technologies	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Describe the blockchain technology, its distributed computing, cryptographic and cryptocurrency primitives.
CO2	Develop blockchain-based solutions and write smart contract using Hyperledger Fabric and Ethereum frameworks.
CO3	Illustrate the concepts of Bitcoin and their usage.
CO4	Implement Ethereum blockchain contract for real-world project development.
CO5	Apply security features in blockchain technologies.

Course Content:

Unit 1:

Introduction: Need for distributed record keeping, Modeling faults and adversaries, Fault-tolerant distributed computing, Paxos, Byzantine Generals Problem, Consensus algorithms and their scalability problems, Nakamoto's concept with Blockchain based cryptocurrency (Bitcoin). Technical concepts of Blockchain systems – Block, Hash pointers and Merkle tree, Digital signature, Public-key cryptography, Digital cash, Zero-knowledge systems, Public vs Private Blockchain, Permissioned model of Blockchain, Concept of Smart Contract.

Unit 2:

Bitcoin And Blockchain: Creation of coins, Payments and double spending problem, Bitcoin scripts, Bitcoin P2P network, Transaction in Bitcoin network, Block mining, Block propagation and Block relay. Consensus in Bitcoin – Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW): Basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake (PoS), The life of a Bitcoin Miner, Mining Difficulty, Mining Pool. Ethereum Basics – Ethereum and Smart Contracts, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum smart contracts, Writing smart contracts using Solidity & JavaScript.

Unit 3:

Security And Privacy Issues: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, Scalability problems, Stopping adoption, Network attacks to destroy bitcoin. Attacks on Block-chains: Sybil attacks, selfish mining, 51% attacks, advent of Algorand, Sharding-based consensus algorithms to prevent these attacks

Unit 4:

Block-chain Application Development and Case Studies: Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda. Case Studies – Block chain in Financial Service, Supply Chain Management and Government Services

Text Books:

1. Josh Thompsons, "Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming", Createspace Independent Pub, 2017

2. Imran Bashir, "Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing, 2nd ed., 2018

3. Narayanan, Bonneau, Felten, Miller and Goldfeder, "Bitcoin and Cryptocurrency Technologies– A Comprehensive Introduction", Princeton University Press, 2016

4. Bellaj Badr, Richard Horrocks, Xun (Brian) Wu, "Blockchain By Example: A developer's guide to creating decentralized applications using Bitcoin, Ethereum and Hyperledger", Packt Publishing Limited, 2018.

5. Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, 2018

Course Code: CSTC 313	Pattern Recognition	Pre-Requisites:	Data Structures and Algorithms
Course Title:	CSIC 301	L-T-P-C	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Apply Bayes decision theory and discriminant functions for classification.
CO2	Use density estimation and MLE for pattern recognition.
CO3	Apply PCA and MDA for dimensionality reduction
CO4	Design linear classifiers and basic neural networks.
CO5	Implement advanced models like SVM, RBF, and clustering.

Syllabus:

Unit 1: Introduction Feature Extraction – I, Feature Extraction – II, Bayes Decision Theory - I Bayes Decision Theory – II, Normal Density and Discriminant Function - I Normal Density and Discriminant Function - II Bayes Decision Theory - Binary Features

Unit 2: Maximum Likelihood Estimation Probability Density Estimation – I, Probability Density Estimation - II Probability Density Estimation - III Probability Density Estimation - IV, Dimensionality Problem Multiple Discriminant Analysis.

Unit 3: Principal Component Analysis - Tutorial Multiple Discriminant Analysis - Tutorial Perceptron Criteria - I,Perceptron Criteria - II MSE Criteria, Linear Discriminator Tutorial Neural Network - I Neural Network - II

Unit 4: Neural Network -III/ Hopefield Network RBF Neural Network – I, RBF Neural Network - II Support Vector Machine Clustering -I, Clustering -II Clustering -III

Text Books or Reference Books:

1. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.
2. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001
3. S. Theodoridis and K. Koutroumbas, Pattern Recognition, Academic Press, 2009
4. E. Alpaydin, Introduction to Machine Learning, Prentice-Hall of India, 2010
5. G. James, D. Witten, T. Hastie and R. Tibshirani, Introduction to Statistical Learning, Springer, 2013.

Course Code:	CSTC 308	**Pre-Requisites:**	
Course Title:	Deep Learning	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Fundamental Understanding of Neural network.
CO2	Basic and Advance concept of Deep Learning.
CO3	Application of Deep Learning

Course Content:

Unit-1:

History of Deep Learning, 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.

Unit-2:

Feedforward Networks: Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, autoencoders. Deep Neural Networks: Difficulty of training deep neural networks, Greedy layerwise training.

Unit-3:

Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization), Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs.

Unit-4:

Convolutional Neural Networks: LeNet, AlexNet, ZF-Net, VGGNet,Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks, Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines.

Unit-5:

Recent Trends: Variational Autoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning, Applications: Image based classification, Vision, NLP.

Text Books:

1. Ian J. Goodfellow, Bengio Yoshua, and Aaron Courville. "Deep Learning." An MIT Press book in preparation, 2016.

2. Charu C. Aggarwal “Neural Networks and Deep Learning: A Textbook” Springer Nature, 2018.

3. Seth Weidman “Deep Learning from Scratch: Building with Python from First Principles” O’REILLY, 2019

4. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola “Dive into Deep Learning: Tools for Engagement” CORWIN, 2019

Course Code:	CSTC 310	**Pre-Requisites:**	
Course Title:	Knowledge Representation and Reasoning	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Describe, apply and demonstrate syntactic and semantic formal models for natural language processing.
CO2	Apply and demonstrate knowledge-based learning methods.
CO3	Write Prolog programs to solve automated reasoning tasks and explain how they will execute
CO4	Apply reasoning techniques (transformation to clausal form, resolution, saturation) to establish properties of first-order problems.

Course Content:

Unit-1:

Introduction, Propositional Logic, Syntax and Semantics, Proof Systems, Natural Deduction, Tableau Method, Resolution Method, First Order Logic (FOL), Syntax and Semantics, Unification, Forward Chaining.

Unit-2:

The Rete Algorithm, Rete example, Programming Rule Based Systems, Representation in FOL, Categories and Properties, Reification, Event Calculus, Deductive Retrieval, Backward Chaining, Logic Programming with Prolog

Unit-3:

Resolution Refutation in FOL, FOL with Equality, Complexity of Theorem Proving , Description Logic (DL), Structure Matching, Classification, Extensions of DL, The ALC Language, Inheritance in Taxonomies

Unit-4:

Default Reasoning, Circumscription, The Event Calculus Revisited, Default Logic, Autoepistemic Logic, Epistemic Logic, Multi Agent Scenarios.

Text Books:

1. Ronald J. Brachman, Hector J. Levesque: Knowledge Representation and Reasoning, Morgan Kaufmann, 2004.
2. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India), 2013.

Reference Books:

1. Schank, Roger C., Robert P. Abelson: Scripts, Plans, Goals, and Understanding: An Inquiry into Human Knowledge Structures. Hillsdale, NJ: Lawrence Erlbaum, 1977.

Course Code:	CSTC 312	**Pre-Requisites:**	
Course Title:	Information Retrieval	**L-T-P-C**	3-0-2

Course Outcomes:

At the end of the course, the student will be able to

CO1	Demonstrate knowledge of various retrieval models, such as Boolean, vector space, probabilistic, and language models.
CO2	Develop proficiency in implementing indexing techniques to efficiently organize and retrieve information.
CO3	Evaluate the effectiveness of retrieval systems using appropriate evaluation metrics and methodologies.
CO4	Understand the challenges and techniques involved in web search, including web crawling, link analysis, and ranking algorithms.
CO5	Explore the application of information retrieval techniques in areas such as text mining, information extraction, and question answering.

Course Content:

Unit-1: Fundamental notions: Data vs Information Processing, DIKW model, data vs information retrieval, search system vs search engine, components of search system, type of search system, role of IR process in search system. design challenges and issues, IR Versus Web search, components of IR process/system, search system computing modules(overview): Text Acquisition, Transformation, Indexing, Relevance Estimation, etc. **Unit 2- Building Blocks of IR (Indexing Process)**: Text acquisition: Crawling & Feed, type of Crawling, meta-crawlers, Design challenges of crawling process, Text Transformation**:** Stopping, Stemming, Stemming Strategies & Algorithms etc, Link Analysis, Strategies and Algorithms, Indexing: Details of Indexing process & elements, Inverted indices, web indexes, near-duplicate detection, Index Compression, efficient processing with sparse vectors.

Unit-3: Internals of Retrieval Process: Introduction of Retrieval Model, Role of retrieval model in IR, History of model, Types of retrieval strategy and Evolution: Boolean and Vector-space retrieval models, Language Model based IR, Probabilistic IR, Advanced Models, Relevance Estimation: Term weighting scheme, TF-IDF weighting, cosine similarity, etc. Relevance feedback and query expansion. User Interface, Visual Elements: Visualization Accomplishment & Visualization Implications.

Unit-4: Web Search and IR Paradigms: Web Search Overview, Evolution of WEB (ARPANET, Internet, WWW), Characterizing the Web, Meta-search, Web Search Architectures, Search engine optimization (SEO), Link Analysis and Specialized Search: Link Analysis, Hubs and Authorities, Page Rank and HITS algorithms, Searching and Ranking: Relevance Scoring and Ranking for Web Similarity, Advanced Search Paradigms: Recommendation System: Collaborative filtering, Content-based recommendation of documents and products, Hidden Web: handling “invisible”, Web-Snippet generation, Summarization, Question Answering System, Cross-Lingual Retrieval & Social Media Search.

Text Books:

1. Ricardo Baeza -Yates and Berthier Ribeiro Neto, Modern Information Retrieval: The Concepts and Technology behind Search 2 nd Edition, ACM Press Books 2011.

2. C. Manning, P. Raghavan, and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.

Reference Books:

1. Bruce Croft, Donald Metzler and Trevor Strohman, Search Engines: Information Retrieval in Practice, Addison Wesley, 2009.

2. Mark Levene, An Introduction to Search Engines and Web Navigation, 2 nd Edition Wiley, 2010.

Course Code:	CSTC 401	**Pre-Requisites:**	
Course Title:	Parallel and Distributed Algorithms	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	The students will be able to construct parallel and distributed algorithms.
CO2	They will be able to execute several instructions simultaneously on different processing devices and then combine all the individual outputs to produce the common result.

Course Content:

Unit- I: Introduction

Fundamentals: Models of parallel and distributed computation, complexity measures;

Parallel Programming Models: Shared-memory model (PRAM, MIMD, SIMD), network model (line, ring, mesh, hypercube), performance measurement of parallel algorithms;

Unit- 2: Parallel algorithm design technique for PRAM model

The PRAM Model: balancing, divide and conquer, parallel prefix computation, pointer jumping, symmetry breaking, pipelining, accelerated cascading;

Parallel algorithm design model for PRAM model

list ranking, Euler Tour, sorting, searching and Merging, graph algorithms, string algorithms; parallel complexity and complexity classes NC, P-completeness, lower bounds;

Unit- 3: Parallel algorithm for network models

Interconnection Networks: topologies (arrays and mesh networks, trees, systolic networks, hypercubes, butterfly) and fundamental algorithms, matrix algorithms, *sorting, graph algorithms*, routing, relationship with PRAM models; Asynchronous Parallel Computation; Multiprocessor Algorithms;

Unit- 4: Distributed Algorithms

Distributed Algorithms: models and complexity measures, safety, liveness, termination, logical time and event ordering, global state and snapshot algorithms, mutual exclusion, clock synchronization, election, termination detection, routing, Distributed graph algorithms; Applications of Distributed algorithms.

Text Books:

1. Michael J Quinn, Parallel Computing, TMH
2. Joseph Jaja, An Introduction to Parallel Algorithms, Addison Wesley
3. Mukesh Singhaland Niranjan G. Shivaratri, Advanced Concepts in Operating Systems, TMH
4. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Pearson

Course Code:	CSTC 403	**Pre-Requisites:**	
Course Title:	Cloud Architecture and Networking	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the concept of virtualization and how this has enabled the development of Cloud Computing
CO2	Know the fundamentals of cloud, cloud Architectures and types of services in cloud
CO3	Understand scaling, cloud security and network management
CO4	Design different Applications in cloud
CO5	Explore some important cloud computing driven commercial systems.

Course Content:

Unit 1: Introduction to Cloud Computing: Cloud Computing (NIST Model), Cloud service providers Properties, Characteristics & Disadvantages, Pros and Cons of Cloud Computing, Benefits of Cloud Computing, Cloud computing vs. Cluster computing vs. Grid computing, Role of Open Standards

Unit 2: Cloud Computing Architecture: Cloud computing architecture, Comparison with traditional computing architecture (client/server), Services provided at various levels, How Cloud Computing Works, Role of Networks in Cloud computing, protocols used, Role of Web services

Unit 3: Service Models: Infrastructure / Hardware as a Service, Platform as a Service, Software as a Service, Types of Clouds, Public Clouds, Private Clouds, Hybrid Clouds, Community Clouds, Economics of the Cloud, Open Challenges, Cloud Interoperability and Standards, Scalability and Fault Tolerance

Unit 4: Introduction to virtualization: Need of virtualization - cost, administration, fast deployment, reduce infrastructure cost - limitations Types of hardware virtualization: Full virtualization - partial virtualization - para virtualization Desktop virtualization: Software virtualization - Memory virtualization - Storage virtualization - Data virtualization - Network virtualization,

Unit 5: Service Management in Cloud Computing: Service Level Agreements (SLAs), Billing & Accounting Managing Data, Looking at Data, Scalability & Cloud Services, Database & Data Stores in Cloud Large Scale Data Processing

Unit 6: Cloud Security: Infrastructure Security, Network level security, Host level security, Application-level security, Data security and Storage, Data privacy and security Issues, Jurisdictional issues raised by Data location, Identity & Access Management, Access Control Trust, Reputation, Risk, Authentication in cloud computing

Case Study on Open Source & Commercial Clouds: Eucalyptus, Microsoft Azure, Amazon EC2

Text Books:

1. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
2. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011

3. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012

4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

Course Code:	CSTC 405	**Pre-Requisites:**	
Course Title:	Quantum Computing	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will gain an understanding of

CO1	The basic principles of quantum computing
CO2	The fundamental differences between conventional computing and quantum computing.
CO3	Several basic quantum computing algorithms.
CO4	The classes of problems that can be expected to be solved well by quantum computers.

Course Content:

Unit-1:

Bits and qubits: Introduction to quantum states and measurements with motivating examples, Comparison with discrete classical states.

Linear algebra: Review of linear algebra: vector spaces, linear operators, Dirac notation, the tensor product. **The postulates of quantum mechanics:** Postulates of quantum mechanics, incl. evolution and measurement.

Unit-2:

The quantum circuit model: The circuit model of quantum computation, Quantum gates and circuits, Universality of the quantum circuit model, and efficient simulation of arbitrary two-qubit gates with a standard universal set of gates.

Quantum search: Grover's search algorithm: analysis and lower bounds.

Unit-3:

Quantum Fourier Transform and Quantum Phase Estimation: Definition of the Quantum Fourier Transform (QFT), and efficient representation thereof as a quantum circuit., Application of the QFT to enable Quantum Phase Estimation (QPE).

Application of QFT / QPE Factoring: Shor's algorithm: reduction of factoring to period finding and then using the QFT for period finding.

Unit-4:

Quantum complexity: Quantum complexity classes and their relationship to classical complexity, Comparison with probabilistic computation.

Quantum error correction: Introducing the concept of quantum error correction.

Fault tolerant quantum computing: Elements of fault tolerant computing; the threshold theorem for efficient suppression of errors.

Unit-5:

Adiabatic quantum computing and quantum optimisation: The quantum adiabatic theorem, and adiabatic optimisation. Quantum annealing and D-Wave.

Case studies in near-term quantum computation: Examples of state-of-the-art quantum algorithms and computers, including superconducting and networked quantum computers.

Text Books:

1. Nielsen M.A., Chuang I.L. (2010). Quantum Computation and Quantum Information. Cambridge University Press.
2. Mermin N.D. Quantum Computer Science: An Introduction. Cambridge University Press. (2007)
3. McGeoch, C. Adiabatic Quantum Computation and Quantum Annealing Theory and Practice. Morgan and Claypool. 2014

Course Code:	CSTC 407	**Pre-Requisites:**	
Course Title:	Cognitive Applications of ML	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the principles and concepts of cognitive applications of machine learning.
CO2	Identify and describe various cognitive applications of machine learning in different domains, such as natural language processing, computer vision, and human-robot interaction.
CO3	Apply machine learning techniques to develop cognitive applications for tasks such as text classification, image recognition, and decision-making.
CO4	Evaluate the ethical and societal implications of cognitive applications of machine learning, considering factors such as bias, fairness, privacy, and human-AI collaboration.

Course Content:

Unit-I:

Introduction to Cognitive Applications of Machine Learning: Overview of Machine Learning and its Application, Introduction to Cognitive Computing and its Significance, Ethical Considerations in Cognitive Applications, Neural Network and Deep Learning.

Unit-2:

Cognitive Computing and Natural Language Processing: Introduction to Natural Language Processing, Text Classification and Sentiment Analysis, Named Entity Recognition and Entity Linking, question Answering System. Computer Vision and Cognitive Applications: Introduction to Computer Vision and Image Understanding, Image Classification and Object Detection, Image segmentation and image-to-text generation, Cognitive Applications in Healthcare and Autonomous vehicles.

Unit-3:

Deep Learning and Cognitive Applications: Overview of Deep Learning and Neural Networks, CNN for Image Analysis, RNN for Sequence Data, Generative Models and their Cognitive Applications. Reinforcement Learning and Cognitive System, Cognitive Computing and AI Systems: Introduction to Cognitive Architecture, Knowledge Representation and Reasoning, Cognitive Agent and Multi-agent Systems, Explainable AI and interpretability in Cognitive System.

Unit-4:

Applications of Cognitive Machine Learning: Intelligent virtual assistants and Chatbots, Recommendation systems, Cognitive analytics and decision support systems, Healthcare applications and medical diagnosis. Ethical and Social Implications of Cognitive Machine Learning, Analysis of real-world cognitive machine learning applications.

Text Books:

1. Judith Hurwitz, Marcia Kaufman, and Adrian Bowles, "Cognitive Computing and Big Data Analytics", Wiley, 2015.

2. Vinit Kumar Gunjan andJacek M. Zurada, “Modern Approaches in Machine Learning & Cognitive Science: A Walkthrough” Springer, 2022.

3. Sasikumar Gurumoorthy, Bangole Narendra Kumar Rao andXiao-Zhi Gao “Cognitive Science and Artificial Intelligence Advances and Applications” Springer, 2018.

Reference Books:

1. Dagmar Monett Diaz and Mario Arias Oliva, “Cognitive Computing: Theory and Applications”, Elsevier, 2016.

Course Code:	CSTC 409	**Pre-Requisites:**	
Course Title:	Natural Language Processing	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the algorithmic approach to NLP.
CO2	Understand the sentence structure and the Computational model of Natural Languages.
CO3	Understand the Data Science approach to Machine Translation and its applications.
CO4	Understand Machine Learning approach to NLP.

Course Content:

Unit-1:

Introduction to NLP: Characteristics of Natural Language, Language structure, Sentence Structure, Language analyzer, Lexicon, word formation, Morphology, syntax analysis (parsing), semantics, ambiguity, pragmatics and discourse.

Unit-2:

NLP Algorithms: Understanding Corpus and data attributes, Corpus Formats CSV, JSON, XML, LibSVM, Operations on Text Corpus, Tokenisation, stop words, Term Frequency Inverse Document Frequency (TF-IDF), Text Analysis and word embedding using word2vec, doc2vec, GLoVe, Bag-of-words (BoW).

Unit-3:

Machine Translation and Applications of NLP: Introduction to Machine Translation (MT), Approaches, Structure of Anusaraka: an Interlingua based MT system, Example/Analogy based MT, Word/phrase based MT, Neural MT. Applications of NLP: Sentiment analysis, chatbots, conversational models (Question Answering system) for Digital Assistants

Unit- 4:

Deep learning models for NLP: Neural Net based NLP models: Study of Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Long Short-Term Memory (LSTM) and Gated Recurrent Unit(GRU) using Natural Language Toolkit (NLTK)

Text Books

1 Thanaki, Jalaj, "Python natural language processing". Packet Publishing Ltd, 2017.

2 Cole Howard, Hannes Max Hapke, and Hobson Lane," Natural Language Processing in Action: Understanding, Analyzing, and Generating Text with Python", Manning, 2019.

3 Daniel Jurafsky, James H. Martin,"Speech and Language Processing: An Introduction to Natural Language Processing", Computational Linguistics and Speech, Pearson Publication, 2014.

Reference Books

1 Lawrence Rabiner And Biing-Hwang Juang, “Fundamentals of Speech Recognition”, Pearson Education, 2003.

2 Samuel Burns, “Natural Language Processing: A Quick Introduction to NLP with Python and NLTK” Independently Published, 2019

3 Bird, Steven, Ewan Klein, and Edward Loper. “Natural language processing with Python: analyzing text with the natural language toolkit." O'Reilly Media, Inc.", 2009.

Course Code:	CSTC 411	**Pre-Requisites:**	
Course Title:	Semantic Web	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Apply RDF, OWL, and SWRL syntax for semantic annotations and rule specification for web resources
CO2	Build and visualize rich ontologies using editors such as Protégé.
CO3	Describe Linked Data principles and architecture, as in dbpedia, Wiki, FOAF etc.Perform Linked data analysis and visualization using SPARQL with R/Python.
CO4	Develop a deep insight to the various state-of-the-art technologies of semantic search engine, semantic web browser and semantic recommender systems.

Course Content:

Unit-1:

Knowledge Engineering and the Web of Data, Semantic Web standards:Uniform Resource Identifier (URI) RDF (Resource Description Framework); Ontology Engineering; OWL (Web Ontology Language), SPARQL, Semantic Web mission; concepts of semantic interoperability, integration and automation; concept of metadata and ontology; description logics.

Unit-2:

Methods for developing and evaluating ontologies. Application development using the OWL API, Tableaux Algorithm, DL Reasoning Problems, Canonical forms, Resolution (PL/FOL), OWL and RDF(S) Semantics Basics, Open and Closed world assumptions, Rules for inferring knowledge, First order Logic, RDF-S semantics, Web Ontology Language(OWL), Semantic Web Rule Language(SWRL), Friend-of-a-Friend(FOAF).

Unit-3:

Query languages SPARQL, SWRL (Semantic Web Rules Language); Semantic Technology;Rules, Protége, Ontology Alignment, Ontology Evaluation, More Ontology Design Methodologies, Metadata, Fundamentals of Ontology and its types, monolithic vs. modular ontology, ontology design methodology, ontology learning, ontology learning from text, automated ontology learning process.

Unit-4:

Linked Data Engineering,Semantic (Web) infrastructure, applications and Services; quality of semantic web applications, Relation to Big Data and Industry 4.0, Linked Data Programming, Semantic Annotation, Named Entity Resolution, Semantic Search, Exploratory Search, Linked Data Analytics, Semantic Recommendations.

Text Books

1. A Semantic Web Primer, by Grigoris Antoniou, Paul Groth, Frank van Harmelen and Rinke Hoekstra, Publisher: MIT Press; 3rd edition (September, 2012).
2. Linked Data: Structured Data on the Web, by David Wood, Marsha Zaidman, Luke Ruth, and Michael Hausenblas. Publisher: Manning Publications; 1 edition (January 24, 2014).

3. Learning SPARQL: Querying and Updating with SPARQL 1.1, by Bob DuCharme Publisher: O'Reilly Media; 2 edition (July 18, 2013).

Reference Books:

1. A Developer's Guide to the Semantic Web" by Liyang Yu (Springer Science & Business Media, 2011)

2. Handbook on ontologies" by SteffanStaab and Rudi Studer (Eds.) (Springer Science & Business Media, 2010)

3. Kumar, S. and Baliyan,N., 2018. Semantic Web-based Systems: Quality Assessment Models. Springer.

Course Code:	CSTC 413	**Pre-Requisites:**	
Course Title:	Advances in Data Science	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	To design efficient algorithms for finding patterns and clusters in complex data
CO2	To design techniques for detecting anomalies in data.
CO3	To analyse real data coming from different domains such as medical, transport, environment etc

Course Content: Unit 1:

Pattern Mining: Maximal and Closed Patterns, Pattern Mining in Multilevel, Multidimensional Space, Constraint-Based Pattern Generation: Pruning Pattern Space and Pruning Data Space, Mining High-Dimensional Data and Colossal Patterns, Mining Compressed Patterns by Pattern Clustering, Sequential Pattern Mining

Unit 2:

Advance Clustering: Clustering High-Dimensional Data, Challenges Subspace Clustering, CLIQUE, PROCLUS, Clustering Graph and Network Data, Similarity Measures, Clustering with Constraints

Unit 3:

Anomaly Detection: Types of Anomalies, Statistical Approaches, Proximity Based Approached, Supervised Approaches, Mining Contextual and Collective Anomalies

Unit 4:

Analysis of Complex Data and Case Studies: Algorithms for Analysis of Spatial Data, Graph Data, Text Data, Time Series Data, Case Studies in Different Domains: Medical Domain, Finance, Environment, and Transportation Systems

Text Books:

1. Tan, Pang-Ning, Michael Steinbach, and Vipin Kumar. Introduction to data mining. Pearson Education India, 2016.

2. Han, Jiawei, et al. Data Mining: Concepts and Techniques, Third Edition, Morgan Kaufmann Publishers, 2012.

3. Chandola, V., Banerjee, A., & Kumar, V. (2009). Anomaly detection: A survey. ACM computing surveys (CSUR), 41(3), 1-58.

Reference Books:

1. Ruey S. Tsay "Analysis of Time-series data," Third Edition, Wiley 2014

2. Jonathan Gross and Jay Yellen, Graph Theory and its Applications, Second Edition, CRC Press. 2018

3. Sara Moridpour, Alireza Toran Pour, Tayebeh Saghapour “Big Data Analytics in Traffic and Transportation Engineering: Emerging Research and Opportunities” IGI Global 2019

4. Jørgensen, Sven Erik, ed. Handbook of Environmental Data and Ecological Parameters: Environmental Sciences and Applications. Vol. 6. Elsevier, 2013.

Course Code:	CSTC 415	Pre-Requisites:	
Course Title:	Nature-Inspired Optimization Techniques	L-T-P-C	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Learn mathematical basis as well as the general principles of various Natured Inspired optimization techniques and algorithms.
CO2	Understand and implement the concept of optimization techniques.
CO3	Develop some familiarity with current research problems and research methods in this field.

Course Content:

Unit 1:

Introduction to Algorithms: Optimization, Search for Optimality, Nature-Inspired Metaheuristics, Analysis of Algorithms: Analysis of Optimization Algorithms, Nature-Inspired Algorithms, Parameter Tuning and Parameter Control.

Unit 2:

Random Walks and Optimization: Random Variables, Optimization as Markov Chains, Step Sizes and Search Efficiency, Modality and Intermittent Search Strategy, Importance of Randomization, Eagle Strategy, Simulated Annealing: Annealing and Boltzmann Distribution, SA Algorithm, Unconstrained Optimization, Basic Convergence Properties, Stochastic Tunneling.

Unit 3:

Genetic Algorithms: Role of Genetic Operators, Choice of Parameters, GA Variants, Convergence Analysis, Particle Swarm Optimization: Swarm Intelligence, PSO Algorithm, Firefly Algorithms: Standard Firefly Algorithm, Variants of the Firefly Algorithm, Cuckoo Search: Cuckoo Breeding Behavior, Special Cases of Cuckoo Search.

Unit 4:

A Framework for Self-Tuning Algorithms, How to Deal with Constraints, Multi-Objective Optimization, Other Algorithms and Hybrid Algorithms: Ant Algorithms, Bee-Inspired Algorithms, Differential Evolution.

Text Books:

1. Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier publications, First Edition, 2014.

Reference Books:

1. Nazmul Siddique, Hojjat Adeli, Nature-Inspired Computing Physics- and Chemistry-based Algorithms, First Edition, 2017.

Course Code:	CSPE 302	**Pre-Requisites:**	
Course Title:	Advanced Database Management Systems	**L-T-P-C**	3-0-2-4

Course Outcomes:
At the end of the course, the student will be able to

CO1	To comprehend issues and solutions of distributed databases.
CO2	To develop understanding of design and implementation of distributed databases.

Course Content:

Unit-1 (Introduction and Distributed Database Design)

Introduction: What is a Distributed Database System? Data Delivery Alternatives, Promises of DDBSs, Design Issues, Distributed DBMS Architecture.

Distributed Database Design: Data fragmentation, allocation, combined approaches, adaptive approaches, data directory.

Unit-2 (Distributed Data Control)

View management, access control, and semantic integrity control.

Unit-3 (Distributed Query Processing)

Overview, data localization, join ordering in distributed queries, distributed cost model, distributed query optimization, adaptive query processing.

Unit-4 (Distributed Transaction Processing)

Background and terminology, distributed query control, distributed concurrency control using snapshot isolation, distributed DBMS reliability, modern approaches to scaling out transaction management.

Unit-5 (Data Replication)

Consistency of replicated databases, update management strategies, replication protocols, group communication, replication and failures.

Text Books:

1. Principles of Distributed Database Systems by M. Tamer Özsu and Patrick Valduriez Fourth Edition, Springer.

Course Code:	CSPE 407	**Pre-Requisites:**	
Course Title:	Medical Image Computing	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	At the end of the course the students will also develop the skills that are vital to medical image-based diagnosis.
CO2	Students should have fundamental skills and understanding of medical image modalities and basic processing approach.
CO3	Students should have segmentation, analysis and learning based diagnosis approach.

Course Content:

Unit-I:

Introduction to Medical Imaging, Basic image processing techniques, Noise and error propagation and methods to handle it, Medical image Enhancement, Introduction to medical Imaging Modalities and image analysis softwares.

Unit-2:

Image registration: Rigid models, Non-Rigid models, Image registration Application and demonstration, Texture in Medical Images, Medical Image segmentation: Region Growing and Clustering, Random Walks for Segmentation, Active Contours for Segmentation, Systematic Evaluation and Validation, Decision Trees for Segmentation and Classification, Random Forests for Segmentation and Classification, Neural Networks for Segmentation and Classification

Unit-3:

Image Analysis, Analysis of Speckle Images: Ultrasound, Doppler and tissue harmonic, Speckle reduction, beam steering, image compounding and filtering, Cardiovascular and Ophthalmic imaging, Learning based Image Analysis, Deep Learning for Medical Image Analysis,

Unit-4:

Retinal Vessel Segmentation and Classification, Vessel Segmentation in CT Scan of Lungs, Lesion Segmentation in Brain MRI, Tissue Characterization in Ultrasound, Learning based diagnosis, Application: Classification and Diagnosis of Brain Tumer, Lung Cancer, retinal disease, cardiovascular disease, other

diseases.

Text Books:

1. G. R. Sinha, Bhagwati Charan Patel, “Medical Image Processing Concepts and Applications” PHI, 2014.

2. Geoff Dougherty “Digital Image Processing for Medical Applications” Cambridge University Press, 2010.

3. Rasmus R. Paulsen, Thomas B. Moeslund, “Introduction to Medical Image Analysis”, Springer, 2020.

4. S. Kevin Zhou, Hayit Greenspan, Dinggang Shen, “Deep Learning for Medical Image Analysis” Academic Press, 2017

Reference Books:

1. Geoff Dougherty "Digital Image Processing for Medical Applications" Cambridge University Press, 2010.

Course Code:	CSPE	**Pre-Requisites:**	
Course Title:	Information Security	**L-T-P-C**	3-0-2-4

Course Outcomes:

At the end of the course, the student will be able to

CO1	Able to understand the information security and number theory concepts.
CO2	Able to analyses different aspects of access control, system security and its applications.
CO3	Able to understand and analyse various cryptographic algorithms.
CO4	Able to design and develop security solutions for different operation systems and networks

Course Content:

Unit 1:

Introduction to Information Security: Meaning of Information security, privacy, vulnerability, threat, attack, CIA Triad, CNSS Security Model, Components of an Information System, OSI Security Architecture, Model for Network Security, Network Access Security Model, Access Control

Unit 2:

Introduction to Number theory: Divisibility, Division Algorithm, Euclidean Algorithm, Extended Euclidean Algorithm, Fast exponentiation Algorithm; Modular Arithmetic, Congruences, Chinese Remainder Theorem, Algebraic structures, Galois Fields

Unit 3:

Introduction to Cryptography: Private Key Cryptography: Traditional Symmetric-key ciphers, Modern Symmetric Key ciphers, Data Encryption Standard (DES), Advanced Encryption Standard (AES), Block Cipher modes of Operation; Public Key Cryptography: Trapdoor one-way Function, RSA, Diffie-Hellman Key exchange, Cryptographic Hash Function, Digital Signature

Unit 4:

System and Operating Security: Overview, Security policy, File Protection Mechanisms, User Authentication, Security models, Trusted Operating System Design, Host based Intrusion detection system, Network based Intrusion detection system, Host based Intrusion prevention system, Network based Intrusion prevention system.

Unit 5:

Network Security: Network security Concepts, Network threats, Security controls, Firewalls, Protecting Programs and Data, Secure Program, sniffing, spoofing, Non Malicious Program errors, Malware, Viruses and other malicious code, Control against Program, Honeypot, SDN Security, IoT Security.

Assignment (Implementation of any Security algorithm from above related topics, as an assignment)

Text Books:

1. Charles P. Pfleeger, Share Lawrence Pfleeger, Security in Computing, Pearson Education, 2/e.
2. William Stallings, Cryptography and Network Security, PHI, 7/e
3. Neal Koblitz, A Course in Number Theory and Cryptography, Springer 2006.
4. B.A. Forouzan, Cryptography and Network Security, McGraw-Hill, 3/e

Reference Books:

1. An Introduction to theory of numbers, Niven, Zuckerman and Montgomery, (Wiley 2006)
2. Charlie Kaufman, Perlman & S Peeciner, Network Security, Pearson Education, 2/e.

Course Code:	CSTC 406	**Pre-Requisites:**	
Course Title:	Cloud Computing	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Explain fundamental computing paradigms and the evolution of cloud computing, along with its advantages, challenges, and real-world applications.
CO2	Describe cloud architecture, various service models (IaaS, PaaS, SaaS), and deployment models to understand cloud-based solutions.
CO3	Analyze virtualization techniques, cloud resource management, and cloud storage solutions used in real-world cloud platforms.
CO4	Evaluate cloud security mechanisms, service management, and case studies to understand best practices and emerging trends in cloud computing.

Course Syllabus:

Unit 1: Fundamentals of Cloud Computing

Introduction to Computing Paradigms: Evolution of Computing: Grid, Cluster, Distributed, Utility, and Cloud Computing, Recent Trends in Computing

Introduction to Cloud Computing: Definition & History of Cloud Computing, Cloud Computing (NIST Model), Business Drivers for Cloud Adoption, Pros, Cons, and Benefits of Cloud Computing, Comparison: Cloud Computing vs. Cluster Computing vs. Grid Computing

Unit 2: Cloud Architecture and Service Models

Cloud Architecture: Cloud Computing Stack, Traditional Computing vs. Cloud Computing, Role of Networks & Web Services in Cloud Computing, Cloud Service Models (XaaS): Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS)

Cloud Deployment Models: Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud

Unit 3: Virtualization, Cloud Platforms, and Management

Infrastructure as a Service (IaaS): Virtualization & Its Approaches, Hypervisors, Machine Images, Virtual Machines (VM), Resource Virtualization (Server, Storage, Network), Cloud Storage and Provisioning (e.g., Amazon EC2, Eucalyptus)

Platform as a Service (PaaS): Introduction to PaaS & Service-Oriented Architecture (SOA), Cloud Platforms & Management

Software as a Service (SaaS): Web Services, Web 2.0, Web OS, Case Studies on SaaS

Unit 4: Cloud Security, Management, and Case Studies

Cloud Service Management: Service Level Agreements (SLAs), Billing & Accounting in Cloud, Scaling: Traditional vs. Cloud, Large-Scale Data Processing in Cloud.

Cloud Security: Security at Network, Host, and Application Levels, Data Privacy, Security Issues & Jurisdictional Concerns, Identity & Access Management, Authentication, Cloud Contracting Model & Business Considerations.

Case Studies on Open Source & Commercial Clouds

Text and Reference Books:

1. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
2. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011
3. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012
4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

Course Code:	CSTC 416	**Pre-Requisites:**	
Course Title:	Data Visualization using R	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Explain fundamental concepts of data visualization, including the importance, challenges, and principles of effective visual representation.
CO2	Apply various visualization techniques, including basic and advanced plotting methods, to effectively represent different types of data.
CO3	Develop interactive and animated data visualizations using modern tools and libraries such as Matplotlib, Seaborn, Plotly, and Altair.
CO4	Evaluate visualization techniques using cognitive and perceptual principles and design effective dashboards for decision-making in real-world applications.

Course Syllabus:

Unit 1: Foundations of Data Visualization

Introduction to Data Visualization: Importance and Applications, External Representations, Interactivity in Visualization, Challenges in Validation

Data and Task Abstraction: Types of Datasets and Attributes, Semantic Meaning of Data, Task Abstraction: Analyze, Produce, Search, Query

Fundamentals of Visual Encoding: Marks and Channels, Rules of Thumb for Visualization Design, Arranging Tables, Spatial Data, and Networks

Unit 2: Basic and Applied Visualizations

Basic Plotting Techniques: Line Plot, Bar Plot, Pie Chart, Scatter Plot, Histogram, Stacked Bar Charts, Subplots, Introduction to Matplotlib, Seaborn, and Plotly

Advanced Visual Representations: Box Plot, Density Plot, Area Chart, Heatmap, Tree Map, Graph Networks, Choosing the Right Visualization for the Right Data

Unit 3: Interactive Visualizations and Animations

Interactive Data Visualizations: Dynamic Charts and Maps, Altair and Plotly for Interactive Visualizations, Juxtaposing and Coordinating Views

Animation and Motion Graphics: 2D & 3D Animation Techniques, Motion Animations in Data Visualization, Real-time Data Visualization

Unit 4: Principles of Information Visualization and Dashboard Design

Cognitive and Perceptual Principles: Visual Perception and Cognition, Gestalt's Principles in Visualization, Tufte's Principles for Effective Data Representation

Dashboard Design and Case Studies: Information Visualization in Decision-Making, Designing Effective Dashboards, Case Studies and Industry Applications

Textbooks and References:

1. R Graphics Essentials for Great Data Visualization by Alboukadel Kassambara
2. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly.
3. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

Course Code:	CSTC 417	**Pre-Requisites:**	
Course Title:	Generative AI	**L-T-P-C**	3-0-0-3

Course Outcomes:
At the end of the course, the student will be able to

CO1	Understand the Foundations of Generative AI
CO2	Apply Generative AI Techniques to Language Models
CO3	Develop AI-Powered Applications Using LangChain and RAG Models
CO4	Evaluate Ethical Considerations and Multimodal AI Applications

Course Syllabus:

Unit 1: Introduction to Generative AI and Mathematical Foundations: Overview of Generative AI: Definition, Importance, and Applications, Mathematical and Computational Foundations of Generative Modeling, Generative Models: Introduction to Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), and Transformer-based Models, Language Models and Large Language Model (LLM) Architectures

Unit 2: GPT Models and Prompt Engineering: GPT (Generative Pretrained Transformer): Architecture and Working, Pre-training and Fine-tuning Processes of GPT Models, Overview of GPT Variants: ChatGPT, GPT-3, GPT-4, etc. ,Improving GPT Performance through Optimization Techniques.

Prompt Engineering: Strategies for Designing Effective Prompts, Techniques for Controlling Model Behavior and Output Quality.

Unit 3: LangChain and Retrieval-Augmented Generation (RAG) Models:

Introduction to LangChain: LangChain Framework and Its Components, Streamlining Application Development Using LangChain, Examples of Applications Built with LangChain

Retrieval-Augmented Generation (RAG) Models: Embeddings, Indexing Networks, and Vector Databases, Use of RAG in Improving AI Responses

Unit 4: Generative AI Applications, Multimodal AI, and Ethical Considerations:

Generative AI Across Modalities: Text, Code, Image, Audio, and Video Generation, Text-to-Image Models and Multimodal Generative AI

Ethical Considerations and Challenges: Understanding Ethical Implications of Generative AI, Addressing Bias and Fairness in Generative AI Systems, Ensuring Responsible Use and Deployment of Generative Models.

Use Cases of Generative AI in Various Domains.

Textbooks and References:

1. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016.
2. Brian Christian, The Alignment Problem: Machine Learning and Human Values. New York: WW Norton & Company, 2020.
3. Roman V Yampolskiy, Artificial Intelligence Safety and Security, Taylor & Francis, 2018.
4. Fabian Gloeckle, Badr Youbi Idrissi, Baptiste Roziere, David Lopez-Paz, Gabriel Synnaeve, Better & Faster Large Language Models via Multi-token Prediction, arXiv:2404.19737v1, 30 Apr 2024.
5. A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, Ł. Kaiser, and I. Polosukhin, "Attention Is All You Need," in Proceedings of the Thirty-First Conference on Neural Information Processing Systems (NeurIPS), 2017.