CURRICULUM & SYLLABI

B.Tech. MATHEMATICS & COMPUTING

Effective from AY: 2025-26

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION
Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship, and Technological services to society

MISSION
- Imparting total quality education to develop innovative, entrepreneurial, and ethical future professionals fit for a globally competitive environment.
- Allowing stakeholders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth- creating centre to serve the societal needs.

Vision and Mission of the Department
COMPUTATIONAL & DATA SCIENCE

VISION
To build an international reputation as a center of excellence in Computational & Data Science research, training, and education, and to inculcate scientific thinking to meet the challenges and growth of science and technology as well as the needs of industry and society, with moral and ethical responsibility.

MISSION
- Imparting quality education through well-designed curriculum in tune with the challenging formal models and software system needs of the industry.
- Providing state-of-art research facilities to generate knowledge and develop technologies in the thrust areas of Computational and Data Science.
- Developing linkages with world class organizations to strengthen industry-academia relationships for mutual benefit

Program: B.Tech. Mathematics & Computing

Program Educational Objectives

PEO-1	Provide sufficient understanding of the fundamentals of mathematics with computational techniques and program core to address challenges faced in Data Science, Computing and other related interdisciplinary fields.
PEO-2	Facilitate as a deep learner and have progressive careers in Industry, research organizations, national/international laboratories, and academia.
PEO-3	Communicate effectively with team members, apply technologies, and lead industry teams.
PEO-4	Assess computing systems from the perspectives of quality, security, privacy, cost, utility, etiquette, and ethics.
PEO-5	Engage in lifelong learning and career enhancement and adapt to changing professional and societal needs.

Program Articulation Matrix

PEO Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
Imparting quality education through well-designed curriculum in tune with the challenging formal models and software system needs of the industry.	3	3	2	3	2
Providing state-of-art research facilities to generate knowledge and develop technologies in the thrust areas of Computational and Data Science.	2	3	3	3	2
Developing linkages with world class organizations to strengthen industry-academia relationships for mutual benefit	2	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Mathematics & Computing

Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and computer science and engineering to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identity, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.
PO-3	**Design/Development of solutions:** Design solutions for complex computer science and engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
PO-4	**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.
PO-5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex computer science and engineering activities with an understanding of the limitations.
PO-6	**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.
PO-7	**Environment and sustainability:** understand the impact of the professional engineering solutions in societal and environmental contexts, demonstrate the knowledge of, and need for sustainable development.
PO-8	**Ethics:** Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.
PO-9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10	**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.
PO-11	**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.
PO-12	**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

PSO-1	Design algorithms for real world computational problems and analyze their complexities.
PSO-2	Develop a broad theoretical foundation in mathematics and design and develop interfaces among computing subsystems.
PSO-3	Analyze large data samples and discover knowledge to provide solutions to engineering problems.
PSO-4	Analyse, create and develop algorithms and computing systems by applying mathematical approaches to interdisciplinary applications.

CURRICULUM
B.Tech. Mathematics & Computing

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1171	Calculus and Ordinary Differential Equations	3-1-0	4
2	PH1161	Engineering Physics	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	CS1101	Programming & Data Structures	3-0-0	3
5	BT1161	Biology for Engineers	2-0-0	2
6	CS1103	Programming and Data Structures Lab	0-1-2	2
7	IC1101	EAA-I (Games & Sports / Yoga & Wellness)	0-0-0	0
		Total Credits		**18**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1172	Transformation Techniques and Partial Differential Equations	3-1-0	4
2	EE1162	Basic Electrical and Electronics Engineering	3-0-0	3
3	CD1102	Design Thinking	0-1-4	3
4	CD1104	Linear Algebra	3-0-0	3
5	CD1106	Mathematical Foundations of Computer Science	3-0-0	3
6	CD1108	Data Structures and Algorithms	3-0-2	4
7	EE1164	Basic Electrical and Electronics Engineering Lab	0-1-2	2
8	IC1102	EAA-II (Games & Sports / Yoga & Wellness)	0-0-0	0
		Total Credits		**22**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1264	Probability and Statistics	3-0-2	4
2	CD1201	Algebraic Structures	3-0-0	3
3	CD1203	Computer Oriented Numerical Methods	3-0-0	3
4	CD1205	Design and Analysis of Algorithms	3-1-0	4
5	CD1207	Computer Organization and Architecture	3-0-0	3
6	CD1209	Python Programming Lab	0-1-2	2
7	CD1211	Computer Oriented Numerical Methods Lab	0-0-2	1
			Total Credits	**20**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1271	Mathematical Analysis	3-1-0	4
2	CD1202	Optimization Techniques and Queuing Theory	3-1-0	4
3	CD1204	Operating Systems	3-0-0	3
4	CD1206	Database Management Systems	3-0-0	3
5	CD1208	Software Engineering	3-0-0	3
6	CD1210	Operating Systems Lab	0-1-2	2
7	CD1212	Database Management Systems Lab	0-1-2	2
			Total Credits	**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CD1301	Convex Optimization and Applications	3-0-0	3
4	CD1303	Theory of Computation	3-1-0	4
3	CD1305	Computer Networks	3-0-0	3
4	CD1307	Machine Learning	3-0-0	3
5	CD13XX	Professional Elective – I	3-0-0	3
6	CD1381	Fractal Course – I	1-0-0	0.5
7	CD1309	Computer Networks Lab	0-1-2	2
8	CD1311	Machine Learning Lab	0-1-2	2
			Total Credits	**20.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CD1302	Deep Learning	**3-0-0**	**3**
2	CD1304	Parallel and Distributed Computing	**3-0-0**	**3**
3	CD1306	Product Development	**0-1-4**	**3**
4	CD13XX	Professional Elective – II	**3-0-0**	**3**
5	CD13XX	Professional Elective – III	**3-0-0**	**3**
6	CD1382	Fractal Course – II	**1-0-0**	**0.5**
7	CD1308	Deep Learning Lab	**0-1-2**	**2**
8	CD1310	Parallel and Distributed Computing Lab	**0-1-2**	**2**
			Total Credits	**19.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MS1262	Business Essentials for Engineers	3-0-0	3
2	CD14XX	Professional Elective – IV	3-0-0	3
3	CD14XX	Professional Elective – V	3-0-0	3
4		Open Elective-I	2-0-0	2
5	CD1401	Agentic AI Lab	0-1-2	2
6	CD1489	Seminar & Technical Writing	2-0-0	2
7	CD1491	Short-Term Industrial/ EPICS/ Research Experience	2-0-0	2
8	CD1495	Minor Project	2-0-0	2
			Total Credits	**19**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CD14XX	Professional Elective – VI	**3-0-0**	**3**
2	CD14XX	Professional Elective–VII	**3-0-0**	**3**
3	CD14XX	Professional Elective–VIII	**3-0-0**	**3**
4	CD1498	Major Project	**0-0-0**	**6**
Total Credits				**15**

Professional Elective Courses:

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	MA1325	Multivariate Calculus and Measure Theory
2	EC1361	Digital Systems and Microcontrollers
3	EC1362	Principles of Signals and Systems
4	CD1321	Scalable Systems for Data Science
5	CD1323	Algorithmic Algebra

Professional Elective-II, III		
S.No.	**Code**	**Course Title**
1	CD1322	Computational Number Theory
2	CD1324	Information and Coding Theory
3	CD1326	Applied Statistical Methods
4	CD1328	Numerical Linear Algebra
5	CD1330	Time Series Analysis & Forecasting
6	CD1332	Compiler Design
7	CD1334	Object Oriented Programming with JAVA
8	CD1336	Computer Vision and Image Processing
9	CD1338	Advanced Databases
10	CD1340	Bio Informatics

Professional Elective-IV, V		
S.No.	**Code**	**Course Title**
1	CD1421	Cryptography
2	CD1423	Stochastic Models and Applications
3	CD1425	Data Warehousing and Data Mining
4	CD1427	Cloud Computing
5	CD1429	Internet of Things
6	CD1431	Quantum Computing and Algorithms
7	CD1433	Social Media Analytics
8	CD1435	Pattern Recognition
9	CD1437	Foundations of Blockchain Technology

Professional Elective-VI, VII, VIII		
S.No.	**Code**	**Course Title**
1	CD1422	Fuzzy Mathematics
2	CD1424	Multiobjective Programming
3	CD1426	Computational Geometry
4	CD1428	Dynamical Systems
5	CD1430	Game Theory
6	CD1432	Algorithmic Techniques for Big Data
7	CD1434	Advanced Theoretical Computer Science
8	CD1436	IoT Security
9	CD1438	Semantic Web
10	CD1440	Cyber Security
11	CD1442	Soft Computing
12	CD1444	Randomized Algorithms

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1163	Calculus and Ordinary Differential Equations	**3-1-0**	**4**
2	PH1161	Engineering Physics	**3-0-2**	**4**
3	MA1172	Transformation Techniques and Partial Differential Equations	**3-1-0**	**4**
4	CD1104	Linear Algebra	**3-0-0**	**3**

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	CS1101	Programming & Data Structures	**3-0-0**	**3**
2	CS1103	Programming and Data Structures Lab	**0-1-2**	**2**
3	BT1161	Biology for Engineers	**2-0-0**	**2**
4	CD1102	Design Thinking	**0-1-4**	**3**
5	EE1162	Basic Electrical and Electronics Engineering	**3-0-0**	**3**
6	EE1164	Basic Electrical and Electronics Engineering Lab	**0-1-2**	**2**
7	CD1306	Product Development	**0-1-4**	**3**

Management, Humanities and Social Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	HS1161	English for Technical Communication	2-0-2	3
2	MS1262	Business Essentials for Engineers	3-0-0	3

The Overall Credit Structure

Course Category	Credits
Basic Science	15
Engineering Science	18
Management, Humanities and Social Sciences	6
Program Core (25 Maths + 52 CS)	77
Professional Elective (3 EC + 9 Maths + 12 CS)	24
Open Elective	2
Seminar and Technical Writing	2
Mini Project	2
Short Term Industrial / EPICS/ Research Experience	2
Fractal Course	1
Major Project	6
Total Graded Credit Requirement	155

Minor Degree in Mathematics & Computing:

Code	Course Title	L-T-P	Credits	Sem.
CD1M01	Elements of Computational Data Science	**3-0-0**	**3**	III
CD1M02	Introduction to Discrete Mathematical Structures	**3-0-0**	**3**	IV
CD1M03	Advanced Data Structures	**3-0-0**	**3**	V
CD1M04	Full Stack Development	**2-0-2**	**3**	VI
CD1M05	Mathematics for Machine Learning	**3-0-0**	**3**	VII

A student should complete a minimum of five courses (15 Credits) to get Minors degree.

Honors Degree in Mathematics & Computing:

Code	Course Title	L-T-P	Credits	Sem.
CS5101	Advanced Algorithms	**3-0-0**	**3**	V
CS5151	Advanced Computer Networks	**3-0-0**	**3**	VI
CS5252	Data Privacy	**3-0-0**	**3**	VI
CS5201	Web and Database Security	**3-0-0**	**3**	VII
MA17003	Functional Analysis	**3-0-0**	**3**	VII

A student should complete a minimum of five courses (15 Credits) to get Honors degree.

SYLLABI

B.Tech. Mathematics and Computing

1st Semester

MA1163 **3-1-0 (4)**

Calculus and Ordinary Differential Equations

Pre-requisites: None

Course Outcomes:

CO-1	Understand to solve the consistent system of linear equations.
CO-2	Apply orthogonal transformations to a quadratic form.
CO-3	Determine the series expansion of a given function.
CO-4	Explore the properties of functions of several variables.
CO-5	Solve arbitrary order linear differential equations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	1	1	1	1
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	–	1	–
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	1	–	1	1
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	–	–	1
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	2	1	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Differential Calculus: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions;Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima andminima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

Integral Calculus: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, Change of order of integration; Change of variables in double and triple integrals.

Vector Calculus: Scalar and vector fields; Vector differentiation; Level surfaces; Directional derivative; Gradient of a scalar field; Divergence and curl of a vector field; Laplacian operator; Parametrization of curves and surfaces; Line, surface and volume integrals; Green's theorem in a plane; Stoke's theorem; Gauss divergence theorem.

Ordinary Differential Equations: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

Learning Resources:

Text Books:

1. **Howard Anton and Chris Rorres**, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, Eleventh Edition.
2. **George B. Thomas and Ross L. Finney**, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition.

3. **Erwin Kreyszig**, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. **Dennis G. Zill**, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition.
2. **R. K. Jain and S. R. K. Iyengar**, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

PH1161 **3-0-2 (4)**

Engineering Physics

Pre-Requisites: None

Course Outcomes:

CO1	Examine the concepts of Interference, diffraction, and polarization to solve engineering problems.
CO2	Assess the technological applications of lasers and optical fibers.
CO3	Apply the quantum mechanical principles for solving engineering problems.
CO4	Understand the basics of nanomaterials and their engineering applications.
CO5	Demonstrate the production, detection, and applications of ultrasonics.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO22	PSO3	PSO4
CO1	3	3	1	1	-	-	-	-	-	-	-	-	3	1		-
CO2	3	3	1	1	-	-	-	-	-	-	-	-	3	1		-
CO3	3	3	2	1	-	-	-	-	-	-	-	-	3	1		-
CO4	3	3	2	1	-	-	-	-	-	-	-	-	3	1		-
CO4	3	3	2	1	-	-	-	-	-	-	-	-	3	1		-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Interference: Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

Diffraction: Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

Polarization: Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

Lasers & Optical Fibers: Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

Quantum Mechanics: Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, Heisenberg uncertainty principle, Schrodinger time independent and time dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunnelling and applications.

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials:

Ultrasonics: Production, detection, and applications of ultrasonics

List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit
11. Strain Gauge
12. Dielectric constant measurements
13. Determination of carrier concentration, charge by using Hall effect experiment
14. Study of I-V characteristics of Solar Cell
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

Learning Resources:

Text Books:

1. Fundamentals of Physics by **Halliday, Resnic and Walker**, John Wiley, Ninth Edition, 2011.
2. Concepts of Modern Physics by **Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury**, McGraw Hill Publications, Sixth Edition, 2009.
3. Engineering Physics by **Shatendra Sharma, Jyotnsa Sharma**, Pearson Education, 2018.
4. Nanotechnology: principles and practices by **Sulabha K. Kulkarnl**. Springer, Third Edition, 2018.
5. Practical Physics by **G.L. Squire**, Cambridge University Press, Fourth Edition, 2001.

Reference Books:

1. Optics by **Ajoy K. Ghatak**, Tata McGraw Hill, Sixth Edition, 2017.
2. Understanding Lasers An Entry-Level Guide, by **Jeff Hecht**, Wiley Publications, Fourth Edition, 2018.
3. A Textbook of Engineering Physics by **M.N. Avadhanulu, P.G. Khirsagar**, Ninth Edition, 2011.
4. University Physics with modern physics, **Hugh D. Young,Roger A. Freedman** Pearson Education, 2014.
5. Nanotechnology the whole story**, B. Rogers, J Adams and S. Pennathur**, CRC Press, 2013.
6. Engineering Physics Practical, **Dr.S.K. Gupta**, Krishna Prakashan Publications, Ninth Edition, 2010.

Online Resources:

1. https://nptel.ac.in/courses/122/107/122107035/

HS1161 **2-0-2 (3)**

English for Technical Communication

Pre-Requisites: English proficiency above B1 level as per the CEFR (Common European Framework of Reference) for languages.

Course Outcomes:

CO-1	Understand and apply principles of technical communication to interact effectively in diverse environments.
CO-2	Analyze complex technical documents to extract and synthesize key information.
CO-3	Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports.
CO-4	Demonstrate the use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions.
CO-5	Interpret technical data presented in the form of graphs, pie charts, and diagrams.
CO-6	Critique and provide constructive feedback on peer communication performances and written works.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	3	–	2	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–
CO-3	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	–	3	–	1	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	2	–	1	–	–	–	–	–	–	–	–	–	–	–
CO-6	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Grammar Principles & Effective Sentence Construction: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- Strategies for Bringing Variety and Clarity in Sentences, - Removing Ambiguity, - Editing Long Sentences for Brevity and Clarity, - Reported Speech, - Contexts for Use of Reported Speech, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

Writing- Paragraph & Letter: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development. - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

Reading Techniques: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

Technical Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy, and Wordiness, - Kinds of

Graphics and Their Messages, - Suitability for Placement in Graphic Representation, - Introduction to Basic Concepts in Research, - Abstract, Keywords, Methodology, Hypothesis, Plagiarism, Critical Reading, - Abstract Writing, - How to Read Scientific Articles, - Basics of Writing a Research Project Proposal, - Preparation and Presentation of Project Reports

Reviews: Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms

Language laboratory:

English Sound System -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription.

Stress and Intonation –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises

Introducing oneself in formal and social contexts- Role plays. - their uses in developing fluency and communication in general.

Oral presentation - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.

Listening Comprehension- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.

Debate/ Group Discussions-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, Drafting – the mindset to avoid writer's block, Checking your own reports and presentations, Giving and receiving constructive feedback.

Learning Resources:

Text Books:

1. English for Engineers and Technologists (Combined edition , Vol. 1 and 2) Orient Blackswan 2010.
2. **Ashraf, M Rizvi**. Effective Technical Communication. Tata McGraw-Hill, 2006
3. **Meenakshi Raman and Sangeetha Sharma**. Technical Communication: Principles and Practice 2nd Edition, Oxford University Press, 2011
4. **Tan, Zhongchao**. Academic Writing for Engineering Publications: A Guide for Non-native English Speakers. Springer, 2022

Reference Books:

1. **Markel, Mike, and Stuart A. Selber**. *Technical Communication*. Bedford/St. Martin's, 2017.
2. **Strunk, William, Jr., and E.B. White**. *The Elements of Style*. 4th ed., Longman, 2000.
3. **Olsen, Leslie A., and Thomas N. Huckin**. *Technical Writing and Professional Communication*. 2nd ed., McGraw-Hill, 1991.
4. **Turabian, Kate L**. *A Manual for Writers of Research Papers, Theses, and Dissertations*. 9th ed., University of Chicago Press, 2018.
5. **Seely, John**. *The Oxford Guide to Writing and Speaking*. Oxford University Press, 2004.
6. **Murphy, Raymond**. *English Grammar in Use*. 5th ed., Cambridge University Press, 2019.
7. **Pinker, Steven**. *The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century*. Viking, 2014.

Other Suggested Readings:

1. **Zinsser, William**. *On Writing Well: The Classic Guide to Writing Nonfiction*. 7th ed., HarperCollins, 2006.
2. **Williams, Joseph M**., and Joseph Bizup. *Style: Lessons in Clarity and Grace*. 12th ed., Pearson, 2016.
3. **Einsohn, Amy, and Marilyn Schwartz**. *The Copyeditor's Handbook: A Guide for Book Publishing and*

Corporate Communications. 4th ed., University of California Press, 2019.
4. **Alley, Michael**. *The Craft of Scientific Writing*. 4th ed., Springer, 2018.
5. **Hofmann, Angelika H**. *Scientific Writing and Communication: Papers, Proposals, and Presentations*. 3rd ed., Oxford University Press, 2016.

CS1101 **3-0-0 (3)**

Programming and Data Structures

Pre-Requisites: None

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems, including stacks, computing, searching, and sorting.
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems.
CO-3	Explore the internals of computing systems to develop efficient algorithms suitably.
CO-4	Examine the suitability of data types and structures to solve specific problems.
CO-5	Apply control structures to develop modular programs to solve mathematical problems
CO-6	Apply object-oriented features in developing programs to solve real world problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	-	2	-	-	2	-	-	-	3	2	-	-
CO-2	3	3	2	2	-	2	-	2	2	-	-	-	3	2	-	-
CO-3	3	3	2	2	-	-	-	2	2	-	-	-	3	2	-	-
CO-4	2	3	2	1	-	2	-	-	2	-	-	-	3	2	-	-
CO-5	2	3	2	2	-	2	-	--	2	-	-	-	3	1	-	-
CO-6	2	3	2	2	-	2	-	-	2	-	-	-	3	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Fundamentals of Computers & Programming – Types of Computers, Components of a computer, Problems, Flowcharts, Memory, Variables, Values, Algorithms, Programs.

Problem-solving techniques – Algorithmic approach, characteristics of algorithm, Problem-solving strategies: Top-down approach, Bottom-up approach, Number systems, and data representation,

Elements of C++ programming language - Data types, constants, and variables, expressions and assignment statements, input and output statements, operators, conditional and branch statements: If-else, Switch-case constructs, Loop statements: while, do-while, for, Arrays – Single and Multi-Dimensional Arrays, strings. Bit-wise operations, static variables.

Functions and Recursion: A Modular approach for solving real-time problems, user-defined functions, library functions, parameter passing—call by value, call by reference, return values, passing arrays as parameters to functions, Recursion.

Searching and sorting - Linear and binary search, bubble sort, selection sort, insertion sort, merge sort, and quick sort.

Structures and Classes: Declaration, member variables, member functions, access modifiers, function overloading, Problems with Complex numbers, Date, Time, and large numbers.

Pointers and Files: An Introduction to pointers and dynamic allocation, String processing, and File

operations—create, read, and write.

Data structures – Introduction, Abstract Data Types (ADTs) –Stack ADT – Array-Based Implementation of Stack – Applications, Queue ADT – Array-Based Implementation – Applications

Learning Resources:

Text Books:

1. **Walter Savitch**, Problem Solving with C++, Pearson, 2014, Ninth Edition.
2. **Chip Weems**, Programming and Problem Solving with C++, Jones and Bartlett Publishers, 2022, 7th Edition.
3. **Langsam, Augenstein & Tenendaum,** Data Structures using C & C++, Pearson, 2015, 2nd Edition.

Reference Books:

1. **R.G. Dromey,** How to solve it by Computer, Pearson, 2008.
2. **Cay Horstmann, Timothy Budd,** Big C++, Wiley, 2009, 2nd Edition.
3. **Yashavant Kanetkar,** Data Structures Through C++, BPB, 2022, 4th Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105151/
2. https://onlinecourses.nptel.ac.in/noc21_cs38/preview

BT1161 **2-0-0 (2)**

Biology for Engineers

Pre-Requisites: None

Course Outcomes:

CO-1	Realize the significance of biomolecules for sustaining life.
CO-2	Identify the difference between unicellular to multi-cellular organisms.
CO-3	Understand heredity, variation and central dogma of life.
CO-4	Apply the concepts of biology for engineering the cell.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	3	2	2	–	–	2	2	–	–	2	–	3	3	3	3
CO-2	3	2	2	–	–	2	–	–	–	–	–	3	3	3	3
CO-3	3	2	2	–	–	2	–	–	–	–	–	3	3	3	3
CO-4	3	3	2	2	1	2	2	1	–	2	–	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Molecules of Life: Chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell, Inside the cell, Cell cycle and Division.

Information processing in living system: Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

Biomolecular machines and motors: Cytoskeletal motor proteins, ATP synthase, Cell motility.

Applied Biotechnology: Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology, Biosafety and Bioethics.

Learning Resources:

Text Books:

1. **Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison**, Biological Science, Pearson Education India, 2016.
2. **Reinhard Renneberg, Viola Berkling and Vanya Loroch**, Biotechnology for Beginners, Academic Press, 2017.

CS1103 **0-1-2 (2)**

Programming and Data Structures Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching, and sorting
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
CO-3	Explore the internals of computing systems to develop efficient algorithms suitably.
CO-4	Examine the suitability of data types and structures to solve specific problems
CO-5	Apply control structures to develop modular programs to solve mathematical problems
CO-6	Apply object-oriented features in developing programs to solve real world problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	-	2	-	-	2	-	-	-	3	2	-	-
CO-2	3	3	2	2	-	2	-	2	2	-	-	-	3	2	-	-
CO-3	3	3	2	2	-	-	-	2	2	-	-	-	3	2	-	-
CO-4	2	3	2	1	-	2	-	-	2	-	-	-	3	2	-	-
CO-5	2	3	2	2	-	2	-	--	2	-	-	-	3	1	-	-
CO-6	2	3	2	2	-	2	-	-	2	-	-	-	3	3	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user-defined functions and library functions.
4. Programs on arrays and matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.
8. Programs on Stacks.
9. Programs on Searching.
10. Programs on Sorting.

Learning Resources:

Text Books:

1. **Walter Savitch**, Problem Solving with C++, Ninth Edition, Pearson, 2014.
2. **Cay Horstmann, Timothy Budd**, Big C++, Wiley, Second Edition, 2009.

Reference Books:

1. **R.G. Dromey**, How to solve it by Computer, Pearson, 2008.
2. **Mark Allen Weiss**, "Data Structures and Algorithm Analysis in C++", Pearson Education, Third Edition, 2006.

2nd Semester

MA1172 **3-1-0 (4)**

Transformation Techniques and Partial Differential Equations

Pre-requisites:

Course Outcomes:

CO-1	Analyze improper integrals for extracting certain properties of beta and gamma integrals.
CO-2	Evaluate multiple integrals in different coordinate systems.
CO-3	Apply the concepts of gradient, divergence and curl of scalar and vector point functions to formulate engineering problems.
CO-4	Find Laplace transforms of functions.
CO-5	Find Fourier Series and Fourier Transforms of functions.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Laplace Transforms: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem.

Fourier Series: Introduction of Fourier series; even and odd functions, periodic function; convergence of Fourier series; Fourier series with arbitrary period; Fourier series for even and odd functions; half range sine and cosine expansions.

Fourier Transforms : Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms.

Equations of the First Order: Formulation of first-order partial differential equations (PDEs); classification of first-order PDEs; Lagrange's method, Cauchy problem, and method of characteristics for linear and quasi-linear PDEs; Pfaffian equation, condition for integrability; first order non-linear equations, complete integrals, envelopes, and singular solutions, method of Charpit.

Equations of higher order: Classification of second-order equations, reduction to canonical forms, and method of solution by separation of variables.

Wave equation: D'Alembert solution of the wave equation, the domain of dependence and range of influence; method of separation of variables; inhomogeneous wave equation, Duhamel's principle.

Diffusion equations: Method of separation of variables, solutions of heat equation with homogeneous and non-homogeneous boundary conditions; inhomogeneous heat equation, Duhamel's principle.

Laplace's equation: Basic concepts; types of boundary value problems; the maximum and minimum principles; boundary value problems; method of separation of variables.

Learning Resources:

Text Books:

1. **I. Sneddon,** Elements of Partial Differential Equations, McGraw Hill, New York, 1984.
2. **T. Amaranath,** An Elementary Course in Partial Differential Equations, 5.Narosa Publishing House, New Delhi, 2003, Second Edition
3. **Erwin Kreyszig,** Advanced Engineering Mathematics, John Wiley and Sons, 2011, 10th Edition.

Reference Books:

1. **P.Prasad and R.Ravindran,** Partial Differential Equations, Wiley Eastern, New Delhi, 1987.
2. **Tyn Myint-U and Lokenath Debnath,** Linear Partial Differential Equations for Scientists and Engineers, Birkhauser, Bostan, 2007, Fourth Edition.

EE1162 **3-0-0 (3)**

Basic Electrical and Electronics Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze DC & AC circuits and determine power & power factor.
CO-2	Understand the specifications of electrical machines.
CO-3	Identify the type of electrical machines for a given application.
CO-4	Analyze basic electronic circuits and estimate the illumination requirements.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	2	2	1	1	1	1	2	1	--	--	--	--
CO-2	3	3	2	2	2	2	1	1	1	1	2	1	--	--	--	--
CO-3	3	3	2	2	2	2	1	1	1	1	2	1	--	--	--	--
CO-4	3	3	2	2	2	2	1	1	1	1	2	1	--	--	--	--

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

DC Circuits: Kirchhoff's Voltage and Current Laws, Superposition Theorem, Star-Delta Transformations.

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1-Phase Series & Parallel Circuits.

Single Phase Transformers: Principle of Operation of a Single-Phase Transformer, EMF Equation, Phasor Diagram, Equivalent Circuit of a 1-Phase Transformer, Determination of Equivalent circuit parameters, calculation of Regulation & Efficiency of a Transformer.

DC Machines: Principle of Operation, Classification, EMF and Torque Equations, Characteristics of Generators and Motors. Speed Control Methods.

AC Machines: 3-Phase Induction Motor- Principle of Operation, Torque – Speed Characteristics of 3- Phase Induction Motor & Applications, Principle of Operation of Alternator- EMF equation.

Illumination: Terminology, Laws of Illumination and Luminance, Luminaries, LED Lighting (Qualitative).

Electric Heating: Principles of resistance heating, induction heating, and dielectric heating. (Qualitative).

Electronic Devices & Circuits: P-type and N-Type semiconductors, P-N junction diode and its I-V characteristics, Single-phase Half-wave and Full wave rectifiers. Bipolar Junction Transistor-operation and CE, CC & CB configurations, Static Characteristics of SCR-MOSFET- IGBT.

Sensors & Transducers: Thermocouple, Thermistor, Resistance Temperature Detector, Hall effect, and Piezoelectric Transducers (Qualitative Treatment only)

Electrical Measuring Instruments: Moving Coil & Moving iron ammeters & voltmeters. Wattmeter's (Qualitative).

Electronics Measurements: Principle of Operation of Digital Multi Meter & Cathode Ray Oscilloscope.

Learning Resources:

Text Books:

1. **Edward Hughes**, Electrical & Electronic Technology, Pearson Education, 2016, 12th Edition.
2. **Vincent Del Toro**, Electrical Engineering Fundamentals, Pearson Education, 2015, 2nd Edition.
3. **V. K Mehtha**, Principals of Electrical & Electronics Engineering, S. Chand Publications, New Delhi, 2010, 3rd Edition.
4. **V N Mittle and Arvind Mittal**, Basic Electrical Engineering, Tata McGraw Hill, 2005, 2nd Edition.

Reference Books:

1. **Millman&Halkias**, Integrated Electronics - Analog and Digital Circuit and Systems, Tata McGraw-Hill Education, 2017, 2nd edition.
2. **U Bakshi& A. Bakshi**, Basic Electrical Engineering, Technical Publications, 2019.
3. A Fitzgerald, Charles Kingsley, Stephen Umans, Electrical Machines, McGraw Hill Education, 2017, 6th edition.
4. **Stephen.J.Chapman**, Electric Machinery, McGraw Hill International Edition, 2017, 4th edition.
5. **P.S. Bimhbra**, Electrical Machinery - Theory, Performance & Applications, Khanna Publishers 2014, 7th edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/108/108108076/

CD1102 **0-1-4 (3)**

Design Thinking

Pre-Requisites: None

Course Outcomes:

CO-1	Identify user needs.
CO-2	Define problems to stimulate ideation.
CO-3	Ideate on problems to propose solutions by working collaboratively.
CO-4	Test aspects of proposed solutions.
CO-5	Improve solutions by gaining user feedback.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2	2
CO-2	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2	2
CO-3	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2	2
CO-4	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2	2
CO5	2	2	2	3	3	3	2	2	3	3	2	3	3	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Engineering: "Engineering" as a vehicle for social and economic development; the impact of science/engineering on our day-to-day lives; the process of engineering a product; various career options.

Introduction and identifying the need: Understanding the unique needs of the user - empathize - define - ideate - prototype - test. Case Studies - Develop an appreciation for the design process and its application in specific settings (Guest lectures, Videos, Field visits, Interplay lectures of design-based movies).

Problem Formulation: Framing a problem statement neutrally using adequate checks. Case studies.

Concept Generation: Generate multiple concepts using various creativity tools and thinking styles.

Prototyping: Select from ideas and make quick prototypes (mock-ups) using available material.
Evaluation: Iterative process of ideation, prototyping and testing-Take the mock-ups to users for feedback and iterate the process till users feel delighted.

Activities:

Some of the activities which are undertaken as a part of this course include:

- Field Visits
- Case Studies on innovation, failures etc
- Guest lecture
- Group Discussions
- Presentation by student
- Experiential learning workshops

Learning Resources:

Text Books:

1. **Andrew Pressman**, Design Thinking: A guide to creative problem solving for everyone, Routledge Taylor and Francis Group, 2019, 1st Edition.
2. **Tim Brown,** Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins e-books; 2009, 1st Edition
3. **George E. Dieter, Linda C. Schmidt,** Engineering Design, McGraw Hill, 2022, 6th Edition.
4. **Ulrich, K., Eppinger, S. and Yang, M**, Product Design and Development, McGraw Hill, 2020, 7th Edition.

CD1104 **3-0-0 (3)**

Linear Algebra

Pre-requisites:

Course Outcomes:

CO-1	Determine the consistency of the system of linear equations.
CO-2	Demonstrate knowledge of vector space and subspaces.
CO-3	Illustrate the concept of inner products and orthogonalization.
CO-4	Solve eigenvalue problems.
CO-5	Apply the SVD of a matrix in finding pseudoinverse and optimal solutions of a linear system of equations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO-2	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO-3	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
CO-4	2	1	1	-	1	-	-	-	-	-	-	-	1	-	-	1
CO-5	3	2	1	-	2	-	-	-	-	-	-	-	3	-	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Systems of Linear Equations: Basic definitions and notations, possible number of solutions of linear equations, elementary row operations, equivalent systems, existence and uniqueness questions.

Vector Spaces: Vector spaces, Subspaces, Linear combinations, and subspaces spanned by a set of vectors, Linear dependence, and Linear independence, Spanning Set and Basis, Finite dimensional spaces, Dimension, Simple systems, Homogeneous and Nonhomogeneous systems, Gaussian elimination, Null Space and Range, Rank and nullity, Consistency conditions in terms of rank, General Solution of a linear system, Elementary Row and Column operations, Row Reduced Form, Triangular Matrix Factorization.

Orthogonality: Inner product, Inner product Spaces, Cauchy – Schwarz inequality, Norm, Orthogonality, Gram – Schmidt orthonormalization, Orthonormal basis, Expansion in terms of orthonormal basis, Orthogonal complement, Decomposition of a vector with respect to a subspace and its orthogonal complement.

Eigenvalues and Eigenvectors: Eigenvalue, Eigenvector pairs – applications, characteristic equation, Algebraic multiplicity, Eigenspaces and geometric multiplicity, Diagonalization criterion, The diagonalizing matrix, Cayley-Hamilton theorem.

Learning Resources:

Text Books:

1. **David C. Lay, Steven R. Lay, Judi J. McDonald**, Linear algebra and its applications, Pearson, 2016, 5th Edition.
2. **Biswa Nath Datta**, Numerical Linear Algebra and Applications, Prentice Hall India/SIAM, 2013/2010,

Second Edition.

Reference Books:

1. **K. Hoffman and R. Kunze**, Linear Algebra, Prentice Hall of India, New Delhi, 2003.
2. **P.G. Bhattacharya, S.K. Jain and S.R. Nagpaul**, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 1991.
3. **S. Kumaresan**, Linear Algebra: A geometric approach, Prentice Hall of India, 2000.

CD1106 **3-0-0 (3)**

Mathematical Foundations of Computer Science

Pre-Requisites: None

Course Outcomes:

CO-1	Apply Propositional logic and first order logic to determine the validity of the statement
CO-2	Construct induction proofs involving summations, inequalities, and divisibility
CO-3	Implement the principles of counting, permutations and combinatory to solve real world Problems
CO-4	Formulate and solve recurrence relations, determine whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram
CO-5	Understand the group structure and possible subgroups.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	–	2	2	3	–	3	–	–	–	–	–	–	–	–	–	–
CO-4	1	2		2	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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.

Counting: Basics of counting, Permutations and combinations - Generalized Permutations and combinations – the Principles of Inclusion– Exclusion, Pigeonhole Principle and its Application.

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

Binary Relations: Binary relations - Properties of binary relations, equivalence relations and partitions, Matrix Representation of relations, Adjacency Matrices, Incidence Matrices, Transitive closure and Warshal's algorithm, Partial and total ordering relations

Groups: Binary operations, Groups, subgroups, cyclic groups – definition, examples, results;, symmetric groups, 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

Learning Resources:

Text Books:

1. **J.R.Mott, A.Kandel and Baker**, Discrete Mathematics for Computer Scientists, PHI, 2006, Third Edition.
2. **C.L. Liu**, Elements of Discrete Mathematics, McGraw Hill, 2017, Fourth Edition.
3. **P.Tremblay** and **R.Manohar**, Discrete Mathematical Structures with applications to Computer Science, **J**McGraw Hill Book Co., 2017
4. **I. N. Herstein**, Topics in Algebra, Wiley, 1975, Second Edition.

Reference Books:

1. **K. H. Rosen**, Discrete Mathematics and its Applications with Combinatorics and Graph Theory, Tata McGraw Hill, 2017, Seventh Edition.
2. **Bernand Kolman, Robert C. Busby, Sharon Cutler Ross**, Discrete Mathematical Structures, PHI, 2008, Sixth Edition.
3. **John B. Fraleigh**, A First Course in Abstract Algebra, Pearson, 2013, Seventh Edition.
4. **Joseph A. Gallian**, Contemporary Abstract Algebra, Cengage Learning, 2013, Eighth Edition

CD1108 **3-0-2 (4)**

Data Structures and Algorithms

Pre-Requisites: CS1101

Course Outcomes:

CO-1	Understand the concept of ADT, identify data structures suitable to solve problems.
CO-2	Develop and analyze algorithms for stacks, queues.
CO-3	Develop algorithms for binary trees and graphs.
CO-4	Implement sorting and searching algorithms.
CO-5	Implement symbol table using hashing techniques and multi-way search trees.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	1	1	1	-	-	-	-	-	-	3	3	2	3
CO-2	3	3	3	2	1	-	-	-	-	-	-	-	3	3	2	3
CO-3	3	3	3	2	1	2	-	-	-	-	-	-	3	3	2	3
CO-4	3	3	3	3	2	1	-	-	-	-	-	-	3	3	2	3
CO-5	3	3	3	3	1	2	-	-	-	-	-	-	3	3	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Iterative and Recursive Algorithms: Abstract Data Types (ADTs), Implementation and Applications of Stacks, Operations and Applications of Queues, Array Implementation of Circular Queues, Implementation of Stacks using Queues, Implementation Queues using Stacks, Linked Lists, Search and Update Operations on Varieties of Linked Lists, Linked List Implementation of Stacks and Queues.

Trees: Introduction, Implementation of Trees, Binary Trees, Tree Traversals with an Application, Binary Search Trees (BSTs), Query and Update Operations on BSTs, AVL Trees, Rotations, Search and Update Operations on Balanced BSTs, Splay Trees, B-trees, Trie, C-Trie.

Hashing: Implementation of Dictionaries, Hash Function, Collisions in Hashing, Separate Chaining, Open Addressing, Analysis of Search Operations.

Priority Queues: Priority Queue ADT, Binary Heap Implementation and Applications of Priority Queues, Disjoint Sets.

Sorting Algorithms: Stability and In Place Properties, Insertion Sort, Merge Sort, Quick Sort, Heap Sort, Lower Bound for Comparison Based Sorting Algorithms, Linear Sorting Algorithms: Counting Sort, Radix Sort, Bucket Sort.

Graph Algorithms: Graphs and their Representations, Graph Traversal Techniques: Breadth First Search (BFS) and Depth First Search (DFS), Applications of BFS and DFS, Minimum Spanning Trees (MST), Prim's and Kruskal's algorithms for MST, Connected Components, Dijkstra's Algorithm for Single Source Shortest Paths, Biconnected Components.

Learning Resources:

Text Books:

1. **Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest** and **Clifford Stein**, Introduction to Algorithms, Second Edition, PHI, 2009.
2. **Mark Allen Weiss**, Data Structures and Algorithm Analysis in C++, Third Edition, Pearson Education, 2006

Reference Books:

1. **Ellis Horowitz, Sartaj Sahni** and **Sanguthevar Rajasekaran**, Fundamentals of Computer Algorithms, Second Edition, Universities Press, 2011.
2. **Michael T.Goodrich** and **Roberto Tamassia**, Algorithm Design: Foundations, Analysis and Internet Examples, Second Edition, Wiley-India, 2006.

EE1164 **0-1-2 (2)**

Basic Electrical and Electronics Engineering Lab

Pre-Requisites: None

Course Outcomes:

CO-1	Select the range of apparatus based on the ratings of DC machines, transformers, and induction machines.
CO-2	Understand the operation of KVL, KCL, and Superposition theorems applied to simple DC circuits.
CO-3	Determine equivalent circuit parameters of transformers by conducting OC and SC tests.
CO-4	Evaluate the performance of DC machines & their braking methods.
CO-5	Evaluate the performance of AC machines and Transformers.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	2	2	2	2	1	2	3	1	1	–	–	–	–
CO-2	3	3	3	2	1	2	1	1	2	3	1	1	–	–	–	–
CO-3	3	3	3	1	1	2	1	1	2	3	1	1	–	–	–	–
CO-4	3	3	3	1	1	2	2	1	2	3	1	1	–	–	–	–
CO-5	3	3	3	1	1	2	2	1	2	3	1	1	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

List of Laboratory Experiments:

1. Electrical verification of Kirchhoff's voltage and current laws.
2. Verification of superposition theorem.
3. Calculation of the power factor and power in a Single phase series *RL* circuit
4. No load test on a DC machine.
5. Load test on a DC shunt generator.
6. Speed control of a DC shunt motor.
7. Determination of equivalent circuit parameters of a single-phase transformer.
8. Determination of efficiency and regulation of a single-phase transformer.
9. Direct load test on a single-phase transformer.
10. Direct Load test on a three-phase induction motor.
11. Static Characteristics of Transistors
12. Half-wave and Full-Wave Rectifiers With R-Load
13. Static Characteristics of MOSFET
14. Static Characteristics of SCR

Learning Resources:

Text Books:

1. **M. E. VanValken Burg,** Network Analysis, PHI, 2015, 3rd Edition.
2. **William H. Hayt, Jack Kemmerly, Steven M. Durbin,** Engineering Circuit Analysis, Tata McGraw- Hill, 2013, 8th Edition.

Reference Books:

1. **M.L.Soni and J.C. Gupta,** A Course in Electrical Circuit Analysis, Dhanpat Rai & Co. (P), 2001.
2. **G.K Mittal & Ravi Mittal,** Network Analysis, Khanna Publications, 2003, 14th Edition.
3. **Gopal G Bhise, Prem R Chadha &Durgesh C. Kulshreshtha Gopal,** Engineering Network Analysis and Filter Design, Umesh Publications, 2012.
4. **S.R. Paranjothi,** Electric Circuit Analysis, New Age International Pub.,2002.
5. **U Bakshi & A. Bakshi,** Basic Electrical Engineering, Technical Publications, 2019, 2019-Edition.
6. **V. K Mehtha,** Principals of Electrical & Electronics Engineering, S. Chand Publications, New Delhi, 2010, 3rd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/102/108102097/
3. https://nptel.ac.in/courses/108/108/108108076/

3rd Semester

MA1264 **3-0-2 (4)**

Probability and Statistics

Pre-requisites: None

Course Outcomes:

CO-1	Check the dependence of random variables.
CO-2	Find the mean and variance of a given probability distribution.
CO-3	Test the hypothesis for small and large samples.
CO-4	Apply techniques for point, interval estimations of parameters of various distributions.
CO-5	Understand Markov Chains and stationary distributions.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-2	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-3	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-4	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–
CO-5	3	3	1	2	1	–	–	–	–	–	–	–	–	1	2	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Review of basics of Probability and descriptive statistics.

Random variables and their distributions: Random variables (discrete and continuous), Probability functions, Density and distribution functions, Mean and variance, two dimensional random variables joint probability mass functions, conditioning and independence

Chebyshev's inequality, Markov's inequality, Chernoff bounds, Weak law of large numbers, central limit theorem, strong law of large numbers.

Probability Distributions: Bernoulli and Poisson processes Special distributions (Binomial, Poisson, Geometric, Uniform, exponential and normal),

Hypothesis Testing: Parameter and statistic, Concept of null and alternative hypotheses, Acceptance and critical regions, Probabilities of Type I and Type II errors, Level and Power of a test. Concept of p-value, Large sample tests (tests for single mean, difference of means, single proportion, difference of proportions), Tests for small samples (t-test for single mean and difference of means, test for comparison of variances),

Estimation: Point and interval estimation, Interval estimation for parameters of normal, binomial and Poisson distributions. Estimation of parameters by maximum Likelihood Estimation method

Stochastic processes, branching processes. Markov chains, classification of states, ideas of stationary distributions. Introduction to Martingales and stopping times.

List of Experiments:

1. Introduction to R Programming
2. Getting Used to R: Describing Data: Viewing and Manipulating Data, Plotting Data, Reading in Your Own Data
3. Visualizing Data: Tables, charts and plots. Visualizing Measures of Central Tendency, Variation, and Shape. Box plots, Finding the mean median standard deviation and quantiles of a set of observations.
4. Common measures of location: Mean, Median, Mode. Common Measures of variation: Range, Variance, Standard Deviation
5. Discrete Distribution: Plots of density and distribution functions of Binomial, Geometric & Poisson Distributions. Fitting of the distributions
6. Continuous distributions: Continuous Probability Distributions (by R): Normal distribution, Exponential, t, F, and other Distributions
7. Confidence Intervals and Tests of Hypotheses, Tests of hypotheses about the population mean, difference of means, and for Population Proportion. Computing the p-value.
8. Correlation: Calculating the correlation between two variables. scatter plots. Use the scatter plot to investigate the relationship between two variables
9. Estimating a Linear Relationship, A Statistical Model for a Linear Relationship, Least Squares Estimates, The R Function lm, Scrutinizing the Residuals

Learning Resources:

Text Books:

1. **S.C.Gupta and V.K.Kapoor**, "Fundamentals of Mathematical Statistics", 12th Edition, S.Chand & Co, 2020.
2. **R. A. Johnson, Miller and Freund's** "Probability and Statistics for Engineers", Pearson Publishers, 9th Edition, 2017.
3. **Maria Dolores Ugarte , Ana F. Militino , Alan T. Arnholt**, Probability and Statistics with R, CRC Press, 2016, 2nd Edition.
4. **P. Dalgaard**, Introductory Statistics with R, Springer 2008, 2nd Edition.

Reference Books

1. **John E. Freund Emeritus, Gary A. Simon**, Modern Elementary Statistics, PHI, 2006, Ninth Edition.
2. **V.K. Rohatgi and A.K. Md. Ehsanes Saleh**, An Introduction to Probability theory and Mathematical Sciences, Wiley, 2001.
3. **Sheldon M. Ross**, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, 2014, Fifth Edition.
4. **Michael Akritas**, " Probability & Statistics with R for Engineers and Scientists", CRC Press, 2016, 2nd Edition.

CD1201 **3-0-0 (3)**

Algebraic Structures

Pre-requisites: None

Course Outcomes:

CO-1	Discover the binary operations as basic entities which give specific mathematical structures to a set
CO-2	Understand the group structure and possible subgroups
CO-3	Analyze the structure of rings and fields
CO-4	Classify groups, rings, fields using isomorphisms between the respective
CO-5	mathematical structures

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	1	-	1	-	-	-	1	1	1	1	2	3	2	2
CO-2	3	3	2	-	-	-	-	-	-	-	-	-	3	3	-	1
CO-3	3	3	2	-	-	-	-	-	-	--	-	-	3	3	-	1
CO-4	3	3	2	2	-	-	-	-	-	-	-	-	3	3	2	1
CO-5	2	2	1	2	1	3	2	2	2	2	2	2	3	3	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Groups: Binary operations, Groups, subgroups, cyclic groups – definition, examples, results; dihedral groups, symmetric groups, the quaternion group as special examples; Equivalence Relations and Partitions; 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, kernel of a group, fibres of homomorphisms, isomorphism, fundamental theorem of isomorphism on groups; Groups of permutations and Cayley's Theorem; Orbits, cycles and the alternating groups

Rings and Fields: Definition of rings and various examples; Units and zero divisors of a ring; Integral domains, Fields, Fermat's and Euler's Theorems; homomorphisms on rings; Ideals and Quotient rings; Rings of polynomials; Factorization of polynomials

Learning Resources:

Text Books:

1. **John B. Fraleigh**: A First Course in Abstract Algebra, Pearson, 2013, Seventh Edition
2. **I. N. Herstein**: Topics in Algebra, Wiley, 1975, Second Edition

Reference Books

1. **Joseph A. Gallian**: Contemporary Abstract Algebra, Cengage Learning, 2013, Eight Edition
2. **Vijay K. Khanna & S. K. Bhambri**: A Course in Abstract Algebra, Vikas Publishing House, 2013,Fourth Edition
3. **David S. Dummit & Richard M. Foote**: Abstract Algebra, Wiley, 2004, Third Edition

CD1203 **3-0-0 (3)**

Computer Oriented Numerical Methods

Pre-requisites: None

Course Outcomes:

CO-1	Find the roots of nonlinear equations numerically.
CO-2	Solve the system of equations numerically.
CO-3	Interpolate the given data.
CO-4	Find differentiation of a function and evaluate definite integrals numerically.
CO-5	Solve the initial value problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	1	2	-	-	-	-	-	-	-	-	2	1	2
CO-2	3	2	2	1	2	-	-	-	-	-	-	-	-	2	1	2
CO-3	3	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2
CO-4	3	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2
CO-5	3	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Computation: Computer Arithmetic - Number system, Fixed point, and floating-point arithmetic; Errors – Sources of errors, Round off errors, Absolute and relative Errors, Error propagation, Loss of significance; Stable and unstable computations, Conditioning.

Root finding: Bisection method, Regula-falsi method, Newton-Raphson method.

Solution of a system of linear equations: LU decomposition, Ill-conditioned equations, Gauss-Jacobi method, Gauss-Seidel method, Jacobi method to find eigenvalues, Solution of tridiagonal system of equations by Thomas algorithm

Interpolation: Lagrange's interpolation, Newton's divided difference interpolation, Newton's forward, backward differences interpolation and Gauss forward, backward interpolation, Sterling's formula.

Numerical Differentiation: First and second-order derivatives approximation with forward, backward, and central differences.

Numerical integration: Newton-Cotes closed type formulae - trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.

Solution of Ordinary differential equations: Initial value problems (IVP's): Single step methods - Taylor's method, Euler's and Modified Euler's methods, Runge-Kutta methods of second and fourth order.

Learning Resources:

Text Books:

1. **V Rajaraman**, Computer Oriented Numerical Methods, Prentice Hall of India, 1993.
2. **M.K.Jain, SRK Iyengar and R.K Jain**, Numerical Methods for Engineers and Scientists, New Age International, 2008.
3. **F.B.Hildebrand**, Introduction to Numerical Analysis, Dover Publications Inc, 2003

Reference Books:

1. **S.S.Sastry**, Introductory Methods of Numerical Analysis, Prentice Hall of India, 2012
2. **S.D. Conte and C. de Boor**, Elementary Numerical Analysis: An Algorithmic Approach, Mc- GrawHill, 1981.

CD1205 **4-0-0 (4)**

Design and Analysis of Algorithms

Pre-Requisites: CS1101, CD1108

Course Outcomes:

CO-1	Understand the basic concepts of algorithms and analysis
CO-2	Analyze time and space complexity
CO-3	Understand algorithm design methodology
CO-4	Apply important algorithm methodology to solve problems
CO-5	Understand the difference between P and NP classes of problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	–	–	–	2	–	–	–	–	–	1	1	1	1
CO-2	–	3	–	–	–	–	–	–	–	–	–	–	3	2	1	1
CO-3	1	2	3	–	–	–	2	–	–	–	–	–	1	1	1	1
CO-4	3	–	3	–	3	3	–	–	–	–	–	–	–	–	2	2
CO-5	1	2	3	–	–	–	2	–	–	–	–	–	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Analysing Algorithms: Concepts in Algorithms Analysis, asymptotic complexity of algorithms, Growth functions Recurrences, Master Theorem.

Divide and Conquer Method: Expected Running Time of Randomized Quick Sort, Merge Sort, Strassen's Matrix Multiplication Algorithm.

Data Structures for Set manipulation problems: Binary tree traversal algorithms, disjoint-set union algorithms.

Graph Algorithms: Representations of graphs, Breadth-first search, Depth-first search, Minimum spanning tree, The algorithms of Kruskal and Prim, Shortest paths, Dijkstra's Algorithm.

Greedy Method: Activity Selection Problem, Knapsack Problem, single source shortest path Problem.

Dynamic Programming: Solution to 0-1 Knapsack Problem, multistage graphs, TSP using Dynamic Programming Backtracking: Basic examples, N-Queen's Problem, sum of subsets Problem.

Complexity Classes: Example NP-complete problems.

Learning Resources:

Text Books:

1. **T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein**, Introduction to Algorithms, PHI, New Delhi, 2004, Third Edition.
2. **E. Horowitz, S. Sahni and S. Rajasekaran**, Fundamentals of Computer Algorithms, Universities Press, 2011, Second Edition.

Reference Books:

1. **A. V. Aho, J. E. Hopcroft and J.D. Ullman**,The Design and Analysis of Computer Algorithms, Pearson, New Delhi, 2012, Tenth Impression.
2. **S. Baase and A.V. Gelder**, Computer Algorithms: Introduction to Design and Analysis, Addison and Wesley, 2000, Third Edition.

CD1207 **3-0-0 (3)**

Computer Organization and Architecture

Pre-Requisites: None

Course Outcomes:

CO-1	Identify functional units, bus structure and addressing modes.
CO-2	Design the hardwired and micro-programmed control units.
CO-3	Identify memory hierarchy and performance.
CO-4	Design Arithmetic Logic Unit.
CO-5	Interface I/O devices.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	2	1	-	-	1	-	-	-	1	-	2	1	1	2
CO-2	2	1	2	-	-	-	1	-	-	-	-	-	2	1	1	1
CO-3	2	1	-	-	1	1	-	-	-	-	-	-	2	2	1	1
CO-4	2	1	2	-	-	1	1	-	-	-	-	-	2	1	1	1
CO-5	1	1	2	1	-	-	1	-	-	-	1	-	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Basic Structures of Computers: Computer Types, Functional Units, Basic Operational Concepts, Bus Structures, Software, Performance, Multiprocessors and multicomputer, Historical Perspective .

Machine instructions and Programs: Numbers, Arithmetic Operations and Characters, Memory Locations and Addresses, Memory Operations, Instructions and Instruction Sequencing, Addressing Modes.

Input/output Organization: Accessing I/O Devices, Interrupts, Processor Examples, Direct Memory Access, Buses, Interface Circuits, Standard I/O Interfaces.

The Memory System: Some Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed Size and Cost, Cache Memories, Virtual Memories, Memory Management Requirements, Secondary Storage.

Arithmetic: Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, Signed-Operand Multiplication, Fast Multiplication, Integer Division, Floating Point Numbers and Operations, Implementing Floating Point Operations.

Basic Processing Unit: Some Fundamental Concepts, Execution of Complete Instruction, Multiple-Bus Organization, Hardwired Control, Micro programmed Control.

.

Pipelining: Basic Concepts, Data Hazards, Instruction Hazards, Influence on Instruction Sets, Data Path and Control Considerations, Super Scalar Operations.

Large Computer Systems: Forms of Parallel Processing, Array Processors, the Structure of General-Purpose Multiprocessors, Interconnection Networks.

Learning Resources:

Text Books:

1. **Carl Hamacher**, "Computer Organization", 5th Edition, McGraw Hill Publishers, 2002.

2. **Wiiliam Stallings**, "Computer Organization and Architecture Designing for Performance", 8th Edition, Pearson Education, 2010.

Reference Books:

1. **John P Hayes**, "Computer Architecture and Organization", 3rd revised Ed., McGraw-Hill, 1998.

CD1209 **0-1-2 (2)**

Python Programming Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the fundamental concepts of Python programming.
CO-2	Develop programs based on iterations and control statements.
CO-3	Analyze the various data formats and their representations.
CO-4	Use various Scientific computing tools and databases.
CO-5	Generate the various data visualizations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	-	2	2	1	-	1	-	3	2	3	1	-	2	-	1
CO-2	1	1	-	1	-	2	1	-	2	1	-	3	1	2	1	-
CO-3	2	1	2	-	2	1	-	1	2	2	3	1	2	3	-	1
CO-4	1	2	-	1	-	2	-	2	3	-	-	1	-	1	2	2
CO-5	1	1	-	1	-	2	-	2	3	1	-	1	1	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Experiments on basic operations-arithmetic operations, string manipulations, input/output functions, control structures-conditional statements, loops; Data structures-lists, tuples, dictionaries, sets; Functions and modules-Defining functions, Lambda functions; File handling-reading and writing files, csv and Json files; Exception handling-error types, try-except blocks, finally clause; OOP- classes and objects, attributes and methods, inheritance, encapsulations, polymorphism.

Accessing databases using python, Experiments on APIs, web development using python programming.

Experiments on libraries-standard (math, random), external (NumPy, Pandas, Matplotlib)

Learning Resources:

Text Books:

1. **Sheetal Taneja**, Python Programming A Modular Approach ,1st Edition Pearson Publications, 2017.
2. **Brett Slatkin** (C), Effective Python: 59 Specific Ways to Write Better Python, I/C, 1st Edition, Pearson Publications, 2015.
3. **Ashok Namdev Kamathane and Amit Ashok Kamathane**, Programming and Problem Solving with Python, 1st Edition, McGraw Hill Education (India) Private Limited, 2017.

References:

1. https://onlinecourses.nptel.ac.in/noc21_cs78/preview
2. https://www.coursera.org/learn/python?specialization=python#syllabus
3. https://www.coursera.org/learn/python-data?specialization=python#syllabus
4. https://www.coursera.org/learn/python-databases?specialization=python#syllabus

CD1211 **0-0-2 (1)**

Computer Oriented Numerical Methods Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Write programs for algebraic and transcendental equations
CO-2	Write the programs to solve a system of linear equations
CO-3	Write a program to find the inverse of a matrix
CO-4	Write programs for the numerical approximation of a definite integral
CO-5	Write programs for the solution of initial value problems

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	1	2	-	-	-	-	-	-	-	-	2	1	2	3
CO-2	2	2	1	2	-	-	-	-	-	-	-	-	2	1	2	3
CO-3	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2	3
CO-4	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2	3
CO-5	3	2	1	2	-	-	-	-	-	-	-	-	2	1	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Solution of algebraic and transcendental equations
   - I. Regula-falsi method when interval is given
   - II. Regula-falsi method when interval is not given
   - III. Newton-Raphson method when initial approximation is given
   - IV. Newton-Raphson method when initial approximation is not given
2. Solution of system of linear equations by Gauss-Seidel i teration method
3. Solution of system of linear equations by Gaussian elimination method
4. Finding the Inverse of a matrix
5. Solution of Tridiagonal system by Thomas algorithm
6. Finding the value of a function using Lagrange interpolation
7. Numerical integration
   - I. Trapezoidal rule
   - II. Simpson's 1/3 rule
   - III. Simpson's 3/8 rule
   - IV. Gauss Legendre quadrature
8. Euler's and modified Euler's methods, Runge-Kutta methods.

Learning Resources:

Text Books:

1. **V Rajaraman**, Computer Oriented Numerical Methods, Prentice Hall of India, 1993.
2. **M.K.Jain, SRK Iyengar and R.K Jain**, Numerical Methods for Engineers and Scientists, New Age International, 2008.

Reference Books:

1. **S.S.Sastry**, Introductory Methods of Numerical Analysis, Prentice Hall of India, 2012
2. **S.D. *Conte* and C. *de Boor***, Elementary Numerical Analysis: An Algorithmic Approach, *Mc- GrawHill,* 1981.

4th Semester

Mathematical Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Describe the fundamental properties of real numbers and complex numbers and their functions that underpin the formal development of mathematical analysis.
CO-2	Adapt with the skills in constructing mathematical arguments while examining the convergence of sequences and series.
CO-3	Understand the concepts related to metric spaces, such as point set topology, limits, and continuity.
CO-4	Examine the concepts of differentiability and analyticity of complex-valued functions, which would lead to an understanding of elementary functions and their properties.
CO-5	Classify the complex-valued functions and their singularities for evaluating certain integrals.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	-	-	-	-	-	-	-	3	2	3	-	3
CO-2	3	3	2	2	-	-	-	-	-	-	-	3	2	3	-	2
CO-3	3	3	2	2	-	-	-	-	-	-	-	2	2	3	-	2
CO-4	3	3	2	2	-	-	-	-	-	-	-	2	2	3	-	2
CO-5	3	3	2	2	-	-	-	-	-	-	-	2	2	3	-	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Sequence and Series of Real Numbers: Finite, countable and uncountable sets; Real number system as a complete ordered field, Archimedean property; Sequences of real numbers, convergence of sequences, bounded sequences, monotonic sequences, Cauchy criterion for convergence; Series of real numbers, convergence, tests of convergence, alternating series, absolute and conditional convergence; Power series and radius of convergence

Metric Spaces and Continuous Functions: Metric spaces; point set topology on metric spaces; open sets; closed sets; Limit of a function on the real line; limits in metric spaces; continuous functions on metric spaces

Calculus: Definition of Riemann integral; existence; properties of Riemann integral; fundamental theorems of integral calculus

Complex Analysis: Review of complex numbers, arguments, roots; Regions in complex plane; Functions of a complex variable – limits, continuity, derivatives, Analytic functions, Singularities; Cauchy-Riemann Equations; Harmonic Functions; Elementary Functions – exponential and logarithmic functions, power functions, trigonometric, hyperbolic and their inverse functions;

Complex Integration: Contour integrals, Cauchy's theorem, Cauchy's integral formula; Taylor's series, Laurent's series, zeros and poles, essential singularities; Residues and Cauchy's residue theorem;

Conformal Mapping: A brief introduction to conformal mapping, mapping by elementary functions, bilinear transformation;

Learning Resources:

Text Books:

1. **Robert G. Bartle and Donald R. Sherbert**, Introduction to Real Analysis, John Wiley & Sons, 2011, Fourth Edition.
2. **Ajit Kumar and S. Kumaresan**, A Basic Course in Real Analysis, CRC Press – Taylor & Francis Group, 2014
3. **James Ward Brown and Ruel V. Churchill**, Complex Variables and Applications, McGraw Hill Education, 2009, Ninth Edition.

Reference Books:

1. **Walter Rudin**, Principles of Mathematical Analysis, McGraw-Hill International Edition, 1976, Third Edition.
2. **Dennis G. Zill and Patrick D. Shanahan**, A First Course in Complex Analysis with Applications, Jones and Bartlett Publishers, 2003
3. **Richard R. Goldberg**, Methods of Real Analysis, John Wiley & Sons, Reprint by Oxford and IBH Publishing, 2020, Second Edition.
4. **S. Ponnusamy**, Foundations of Mathematical Analysis, Birkhäuser - Springer, 2012
5. **Sadhan Kumar Mapa**, Introduction to Real Analysis, Sarat Book Publishers, 2006, Sixth Edition.

MA1202 **3-1-0 (4)**

Optimization Techniques and Queuing Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Apply one-dimensional search methods to find optimal solution
CO-2	Solve unconstrained optimization problems using direct and indirect methods
CO-3	Gain proficiency in constrained optimization techniques
CO-4	Apply suitable optimization methods considering problem constraints
CO-5	Compare the performance of optimization methods under different scenarios.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	1	–	–	3	3	–	3	–	–	–	–	1	1	2	2
CO-2	–	3	2	2	2	–	–	–	–	–	–	–	–	2	1	2
CO-3	3	2	2	2	–	–	–	–	–	–	–	–	2	2	2	1
CO-4	3	1	–	–	3	3	–	3	–	–	–	–	1	1	2	2
CO-5	–	2	–	–	–	–	–	–	–	–	–	–	–	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

One-Dimensional Optimization: Introduction - Unimodal Function - Unrestricted Search - Search with Fixed Step Size - Search with Accelerated Step Size - Exhaustive Search - Dichotomous Search - Interval Halving Method - Fibonacci Method - Golden Section Method -Comparison of Elimination Methods.

Unconstrained Optimization: Classification of unconstrained optimization methods - General Approach - Rate of Convergence - Scaling of Design Variables. Direct search methods -Random Search Methods - Grid Search Method - Univariate Method - Pattern Directions - Powell's Method - Simplex Method. Indirect search methods - Gradient of a Function - Steepest Descent (Cauchy) Method - Conjugate Gradient Method
– Development of Fletcher-Reeves Method - Newton's Method - Marquardt Method - Quasi-Newton Methods – Davidon, Fletcher, and Powell (DFP) Method – Broyden, Fletcher, Goldfarb, Shanno (BFGS) Method.

Constrained Optimization: Characteristics of a Constrained Problem. Direct methods - Random Search Methods - Complex Method - Sequential Linear Programming - Basic Approach in the Methods of Feasible Directions - Zoutendijk's Method of Feasible Directions -Rosen's Gradient Projection Method - Generalized Reduced Gradient Method - Sequential Quadratic Programming. Indirect search methods - Penalty Function Method - Parametric Constraints - Augmented Lagrange Multiplier Method - Convergence of Constrained Optimization Problems.

Queuing theory: Characteristics of queueing systems - The birth and death process - Steady state solutions - Single server model (finite and infinite capacities) - Single server model (with SIRO) - Models with state dependent arrival and service rates- Waiting time distributions.

Learning Resources:

Text Books:

1. **S. S. Rao,** Engineering optimization: theory and practice, Wiley, 2019, Fifth Edition.
2. **K. Deb,** Optimization for Engineering Design: Algorithms and Examples, PHI Learning, 2012, Second Edition.
3. **H. A. Taha**, Operations Research: An Introduction, PHI, Delhi, 2014, Tenth Edition.

Reference Books:

1. **Mokhtar S. Bazaraa, Hanif D. Sherali, C. M. Shetty**, Nonlinear Programming Theory and Algorithms, Wiley, 2013, Third Edition.
2. **M. J. Kochenderfer, T. A.Wheeler,** Algorithms for optimization, MIT Press, 2019, First Edition.
3. **J. C. Pant**, Introduction to Optimization: Operations Research, Jain Brothers, Delhi, 2015, Seventh Edition.

CD1204 **3-0-0 (3)**

Operating Systems

Pre-Requisites: CD1108, CD1207

Course Outcomes:

CO-1	Distinguish functional architectures of operating systems and file systems.
CO-2	Develop algorithms for subsystem components.
CO-3	Design device drivers and multi-threading libraries for an OS.
CO-4	Develop application programs using UNIX system calls.
CO-5	Design and solve synchronization problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	3	2	-	2	-	2	2	2	2	2	3	-	2
CO-2	2	2	3	3	2	-	2	-	2	2	2	2	2	3	-	2
CO-3	2	2	2	3	2	-	2	-	2	2	2	2	2	3	-	2
CO-4	3	2	2	3	2	-	2	-	2	2	2	2	1	3	-	-
CO-5	2	2	2	3	1	-	2	-	2	2	2	2	2	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Batch, iterative, time sharing, multiprocessor, distributed, cluster and real-time systems, UNIX system introduction and commands.

Operating system structures: Computer system structure, Network structure, I/O Structure, Storage Structure, Dual mode operation, System components, Operating-System Services, System Calls, System Programs, System structure, Virtual Machines, System Design and Implementation, System Generation.

Processes and Threads : Process Concept, Process Scheduling, Operations on Processes, Cooperating Processes, Interprocess Communication, Communication in Client – Server Systems, Multithreading Models, Threading Issues, Pthreads Basic Concepts.

CPU Scheduling: Scheduling Criteria, Scheduling Algorithms, Multiple-Processor Scheduling, Real- Time Scheduling, Algorithm Evaluation, Process Scheduling Models.

Process Synchronization: Synchronization Background, the Critical-Section Problem, Synchronization Hardware, Semaphores, Classic Problems of Synchronization, Critical Regions, Monitors, OS Synchronization.

Deadlocks: System Model, Deadlock Characterization, Methods for Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Recovery from Deadlock.

Memory Management: Memory Management Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with Paging, Virtual Memory, Demand Paging, Process Creation, Page Replacement, Allocation of Frames, Thrashing, Operating-System Examples, Other Considerations.

File System: File Concept, Access Methods, Directory Structure, File-System Mounting, File Sharing, Protection File-System Structure, File-System Implementation, Directory Implementation, Allocation Methods, Free-Space Management, Efficiency and Performance, Recovery, Log-Structured File System, NFS.

I/O Systems: Hardware, Application I/O Interface, Kernel I/O Subsystem, Transforming I/O to Hardware Operations, STREAMS, Performance, Disk Structure, Disk Scheduling, Disk Management, Swap-Space

Management, RAID Structure, Disk Attachment, Stable-Storage Implementation, Tertiary-Storage Structure

Learning Resources:

Text Books:

1. **Abraham Silberschatz, Peter Baer Galvin, Greg Gagne**, "Operating System Principles", Wiley, 10th Edition, 2019.
2. **Richard Stevens, Stephen Rago**, "Advanced Programming in the UNIX Environment", Pearson Education, 2nd Edition, 2013.

CD1206 **3-0-0 (3)**

Database Management Systems

Pre-Requisites: CD1108

Course Outcomes:

CO-1	Identify the functional components of database management system with the development of E-R model for real world applications
CO-2	Construct the queries using Relational Algebra, Relational Calculus and SQL
CO-3	Apply the concepts of SQL and its use to construct the databases
CO-4	Design the relational databases using various normal forms and integrity constraints
CO-5	Interpret the concepts of authorization, transfer of privileges, and query processing

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	1	3	3	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	3	1	3	–	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	3	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to DBMS: Historical perspective, File Versus a DBMS, Advantages of DBMS, Describing and storing data in DBMS, Architecture of a DBMS, Different Data Models.

Entity Relationship (ER) model: Features of ER model, conceptual design using ER model, design for large enterprises; Relational model–structure and operations, Integrity constraints over relations.

Query languages: Relational Algebra, Relational Calculus and SQL– Queries, Constraints, Form of SQL query, UNION, INTERSECT and EXCEPT, Nested queries, Aggregate Operators, Null values, Complex Integrity constraints in SQL, triggers and Embedded SQL.

Database Design: Mapping ER model to Relational form; Functional Dependency–Closer of functional dependencies, closer of attributes, canonical cover and Properties of Decompositions; Normalization process – 1NF, 2NF, 3NF and BCNF; Multivalued dependency– Closer properties of Multivalued dependency and 4NF; Join dependency– PJNF, Decomposition Algorithms.

Transaction Management: ACID properties, transactions, schedules and concurrent execution of transactions; Concurrency control – lock-based protocol, Serializability, recoverability, dealing with deadlocks and Concurrency control without locking.

Query Processing: Overview of Query Evaluation, operator evaluation; Algorithms for relational operations– Selection operation, General selection condition, Projection operation, Join operation, set operation and aggregate operation, Evaluation of relational operations; Query optimization: Alternative plans, functions of query optimizer,

translating SQL queries into relational algebra, estimating the cost of a plan, relational algebra equivalences, and other approaches to query optimization.

Database Recovery: Failure classification, Recovery and atomicity, Log-based recovery shadow paging and Advanced Recovery Techniques.

Learning Resources:

Text Books:

1. **Silberschatz, Korth and Sudarshan**, "Database System Concepts", McGraw Hill, 2021, 7th Edition.
2. **Elmasri and Navathe**, "Fundamentals of Database Systems", Pearson Education, 2017,7th Edition.

Reference Books:

1. **Raghu Ramakrishnan, Johannes Gehrke**, "Database Management Systems", McGraw Hill, 2002, 3rd Edition.

Other Suggested Readings:

1. MIT Open Course Ware: https://ocw.mit.edu/courses/6-830-database-systems-fall-2010/

CS1208 **3-0-0 (3)**

Software Engineering

Pre-Requisites: None

Course Outcomes:

CO-1	Comprehend software development life cycle.
CO-2	Prepare SRS document for a project.
CO-3	Apply software design and development techniques.
CO-4	Identify verification and validation methods in a software engineering project.
CO-5	Implement testing methods for software.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	1	1	2	1	-	2	2	2	-	1	2	1	2
CO-2	2	1	2	-	-	2	2	-	2	2	-	-	-	1	-	2
CO-3	2	2	2	1	-	1	1	-	-	2	1	-	2	2	1	2
CO-4	2	2	2	-	2	2	2	-	2	2	1	-	-	1	-	3
CO-5	2	2	2	-	2	2	2	-	2	2	1	-	1	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

The Software Problem - Cost, Schedule, and Quality, Scale and Change ; Software Processes- Process and Project , Component Software Processes; Software Development Process Models – Waterfall Model, Prototyping, Iterative Development , Rational Unified Process , Time boxing Model , Extreme Programming and Agile Processes, Using Process Models in a Project. Software Requirements Analysis and Specification - Value of a Good SRS, Requirement Process, Requirements Specification.

Formal Specification- Formal Specification in the Software process, Sub-system interface specification, Behavioural Specification; Desirable Characteristics of an SRS - Components of an SRS, Structure of a Requirements Document; Functional Specification with Use Cases - Basics , Examples , Extensions, Developing Use Cases; Other Approaches for Analysis - Data Flow Diagrams , ER Diagrams , Validation.

Software Architecture - Role of Software Architecture, Architecture Views – Component and Connector View - Components, Connectors, An Example. Architecture Styles for C&C View - Pipe and Filter, Shared-Data Style , Client-Server Style, Some Other Styles, Documenting Architecture Design - Evaluating Architectures; Design - Design Concepts - Coupling , Cohesion , The Open-Closed Principle . Function-Oriented Design (from Pressman) - Structure Charts, Structured Design Methodology, An Example. Object- Oriented Design (from Jalote)- OO Concepts, Unified Modeling Language (UML) , A Design Methodology , Examples; Detailed Design - Logic/Algorithm Design, State Modeling of Classes; Verification - Metrics - Complexity Metrics for Function-Oriented Design, Complexity Metrics for OO Design; Coding and Unit Testing -Programming Principles and Guidelines - Structured Programming , Information Hiding, Some Programming Practices, Coding Standards; Incrementally Developing Code - An Incremental Coding Process ,Test-Driven Development, Pair Programming; Managing Evolving Code - Source Code Control and Build, Refactoring; Unit Testing -Testing Procedural Units, Unit Testing of Classes; Code Inspection - Planning, Self-Review, Group Review Meeting; Metrics - Size Measures, Complexity Metrics; Testing - Testing Concepts - Error, Fault, and Failure, Test Case, Test Suite, and Test Harness, Psychology of Testing , Levels of Testing.

Testing Process - Test Plan, Test Case Design, Test Case Execution; Black-Box Testing – Equivalence Class Partitioning, Boundary Value Analysis , Pairwise Testing, Special Cases, State-Based Testing; White-Box Testing

- Control Flow-Based Criteria, Test Case Generation and Tool Support; Metrics -Coverage Analysis, Reliability, Defect Removal Efficiency.

Learning Resources:

Text Books:

1. **Pankaj Jalote**, "*Software Engineering Precise Approach*" , Wiley Publishers, 2012.
2. **Rajib Mall**, Fundamentals of Software Engineering, PHI, Fifth Edition , 2018.

Reference Books:

1. **Ian Sommerville**, "*Software Engineering", 8/e* Pearson Publishers, 2012.
2. **Roger Pressman**, "*Software Engineering*", 5th edition, MCgrawHill, 2002.

CD1210 **0-1-2 (2)**

Operating Systems Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Implement elementary UNIX system commands.
CO-2	Develop programs to test synchronization problems.
CO-3	Design and develop user level thread library.
CO-4	Design and implement file system.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	2	2	-	2	-	2	2	2	2	-	2	-	-
CO-2	2	2	2	3	3	-	2	-	2	2	2	2	2	3	-	2
CO-3	2	2	2	3	3	-	2	-	2	2	2	2	2	3	-	2
CO-4	2	2	2	3	3	-	2	-	2	2	2	2	2	3	-	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Write Command Interpreter Programs which accepts some basic Unix commands and displays the appropriate result. Each student should write programs for at least six commands.
2. Study the concept of Signals and write a program for Context Switching between two processes using alarm signals.
3. Study pthreads and implement the following: Write a program which shows the performance improvement in using threads as compared with process. (Examples like Matrix Multiplication, Hyper quicksort, Merge sort, Traveling Sales Person problem)
4. Create your own thread library, which has the features of pthread library by using appropriate system calls (UContext related calls). Containing functionality for creation, termination of threads with simple round robin scheduling algorithm and synchronization features.
5. Implement all CPU Scheduling Algorithms using your thread library
6. Study the concept of Synchronization and implement the classical synchronization problems using Semaphores, Message queues and shared memory (minimum of 3 problems)
7. A complete file system implementation inside a disk image file.

Learning Resources:

Text Books:

1. **Richard Stevens, Stephen Rago**, "Advanced Programming in the UNIX Environment", Pearson Education, Second Edition, 2013.

CD1212 **0-1-2 (2)**

Database Management Systems Laboratory

Pre-Requisites: None

Course Outcomes:

CO-1	Design and Implement a database schema.
CO-2	Devise queries using DDL, DML, DCL and TCL commands.
CO-3	Develop application programs using PL/SQL.
CO-4	Design and implement a project using embedded SQL and GUI.
CO-5	Apply modified components for performance tuning in open source software.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	-	3	2	1	-	1	-	-	1	2	2	2	3	2	2
CO-2	2	-	2	1	2	-	2	1	1	1	1	-	-	1	1	-
CO-3	2	-	2	1	2	-	2	1	1	1	1	3	3	2	-	3
CO-4	-	1	2	1	2	-	1	-	-	2	2	2	2	2	1	2
CO-5	1	2	1	1		-	-	1	-	1	1	2	2	1	-	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Familiarization of Oracle RDBMS, SQL*Plus and Oracle developer,
SQL: query-structure; DDL-create, alter, drop, rename and Truncate; DML-select, insert, update, delete and lock; Set operations- union, intersection and except; join; Aggregate Operations- group-by and having; nested sub-queries and views; DCL-grant and revoke, TCL-Commit, save point, rollback and set transaction.

PL/SQL: Environment, block structure, variables, operators, data types, control structures; Cursors structures- Implicit and Explicit; Bulk statements- Bulk collect into and forall; Exception handling Compilation and Run-time, user-defined; Stored procedures- creation options, pass-by-value and functions-pass-by-value; Packages-package specification, body, package creation and usage; Triggers Data definition language triggers, Data manipulation triggers, Compound triggers and trigger restrictions;

Large objects: CLOB, NCLOB, BLOB and BFILE; Implementation of applications using GUI; group project;

Learning Resources:

Text Books:

1. **James, Paul and Weinberg, Andy Oppel**, "SQL: The Complete Reference", McGraw Hill, 2011, 3rd Edition.

5th Semester

CD1301 **3-0-0 (3)**

Convex Optimization and Applications

Pre-Requisites: CD1104

Course Outcomes:

CO-1	Understand and analyze properties of convex sets, convex functions, and generalized inequalities.
CO-2	Formulate real-world problems as convex optimization models, including linear, quadratic, and geometric programs.
CO-3	Apply duality principles to derive and interpret Lagrange dual problems and optimality conditions.
CO-4	Implement and analyze convex optimization algorithms, including sub-gradient and cutting-plane methods.
CO-5	Identify and solve convex optimization problems arising in probabilistic models and machine learning applications.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	2	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO-4	2	2	-	2	2	-	-	-	-	-	-	-	-	-	-	-
CO-5	2	-	2	-	2	-	-	-	-	-	2	-	-	-	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Convex sets and functions: Affine and convex sets, Operations that preserve convexity, generalized inequalities, Separating and supporting hyperplanes, Dual cones and generalized inequalities. Operations that preserve convexity, The conjugate function, Quasiconvex functions, Logconvex and logconcave functions

Convex optimization: Formulating problems, Linear programs, Quadratic and geometric programming, generalized inequality constraints, vector optimization, Using solvers.

Duality: The Lagrange dual function, The Lagrange dual problem, Interpretations, Optimality

Convex optimization algorithms: unconstrained optimization, constrained minimization, Karush-Kuhn-Tucker (KKT) conditions. Sub-gradient methods for non-differentiable functions, Cutting-plane methods, Important standard classes such as linear and quadratic programming, semidefinite programming, (possibly also second-order cone programming), etc.

Applications: The standard classes in probabilistic models and machine learning problems, Recognizing and formulating convex optimization problems in practice.

Learning Resources:

Text Books:

1. Boyd, Stephen P., and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.
2. Nocedal, Jorge, and Stephen J. Wright, eds. Numerical optimization. New York, NY: Springer New York, 1999.

Reference Books:

1. Bertsekas, Dimitri. Convex optimization theory. Vol. 1. Athena Scientific, 2009.
2. Bertsekas, Dimitri. Convex optimization algorithms. Athena Scientific, 2015.
3. Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.

Other Resources:

1. https://archive.nptel.ac.in/courses/111/104/111104068/
2. https://ocw.mit.edu/courses/6-079-introduction-to-convex-optimization-fall-2009/

CD1303 **3-1-0 (4)**

Theory of Computation

Pre-Requisites:

Course Outcomes:

CO-1	Understand formal machines, languages and computations
CO-2	Design finite state machines for acceptance of strings
CO-3	Design context free grammars for formal languages
CO-4	Develop pushdown automata accepting strings
CO-5	Design Turing machine
CO-6	Distinguish between decidability and undecidability

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	1	1	1	-	-	-	-	-	-	-	2	1	-
CO-2	3	3	2	3	2	2	2	-	2	2	2	2	3	3	2	2
CO-3	3	3	2	3	2	2	2	-	2	2	2	2	3	3	2	2
CO-4	3	3	2	3	2	2	2	-	2	2	2	2	3	3	2	2
CO-5	3	3	2	3	2	2	2	-	2	2	2	2	3	3	2	2
CO-6	2	2	2	1	1	1	-	-	-	-	-	-	-	2	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Finite Automata: Structural Representations. Automata and Complexity, The Central Concepts of Automata Theory, Alphabets, Strings, Languages, Enabling the Automata to Ignore Actions, Deterministic, non-deterministic, Finite Automata with Epsilon-Transitions, Uses of e-Transitions.

Regular expressions: The Operators of Regular Expressions, Building Regular Expressions, Precedence of Regular-Expression Operators, Finite Automata and Regular Expressions, From DFA's to Regular Expressions, Converting DFA's to Regular Expressions by Eliminating States, Converting Regular Expressions to Automata, Applications of Regular Expressions, Regular Expressions in UNIX, Lexical Analysis, Finding Patterns in Text, Algebraic Laws for Regular Expressions, Associativity and Commutativity, Identities and Annihilators, Distributive Laws, The Idempotent Law, Laws Involving Closures, Pumping Lemma

Context Free Grammars: Derivations Using a Grammar, Leftmost and Rightmost Derivations, The Language of a Grammar, Sentential Forms, Parse Tress, Constructing Parse Trees, The Yield of a Parse Tree, Applications of Context-Free Grammars, Parsers, The YACC Parser-Generator, Ambiguity in Grammars and Languages, Ambiguous Grammars, Removing Ambiguity from Grammars.

Push Down Automata: Definition of the Pushdown Automaton, A Graphical Notation for PDA's, Instantaneous Descriptions of a PDA, The Languages of a PDA, Acceptance by Final State, Acceptance by Empty Stack, Equivalence of PDA's and CFG's, Context Free Languages - Properties, Normal Forms for Context-Free Grammars, Eliminating Useless Symbols.

Turing Machines: Introduction to Turing Machines, Problems That Computers Cannot Solve, Notation for the Turing Machine, Instantaneous Descriptions for the Turing Machines, Transition Diagrams for Turing Machines, The Language of a Turing Machine, Turing Machines and Halting, Programming Techniques for Turing Machines, Storage in the State, Multiple Tracks, Shifting Over, Subroutines, Extensions to the Basic Turing-Machines, Multiple Turing Machines, Computable Functions.

Undecidability: A Language that is Not Recursively Enumerable, Enumerating the Binary Strings, Codes for Turing

Machines, The Diagonalization Language, and An Undecidable Problem That is RE, Complements of Recursive and RE Languages, The Universal Language, and Undecidability of the Universal Language

Learning Resources:

Text Books:

1. **John E. Hopcroft, Rajeev Motwani, Jeffrey D Ullman**, Introduction to Automata Theory, Languages and Computation, Pearson, 2001, 2nd Edition.

Reference Books:

1. **Michael Sipser**, Introduction to Theory of Computation, Course Technology, 2012, 3rd Edition.

CD1305 **3-0-0 (3)**

Computer Networks

Pre-Requisites:

Course Outcomes:

CO-1	Understand OSI and TCP/IP models
CO-2	Analyze MAC layer protocols and LAN technologies
CO-3	Design applications using internet protocols
CO-4	Implement routing and congestion control algorithms
CO-5	Develop application layer protocols

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO-3	3	2	3	-	3	-	-	-	-	-	-	2	2	2	-	2
CO-4	1	2	2	1	-	-	-	-	-	-	-	-	2	2	-	-
CO-5	3	3	3	-	3	-	1	1	-	-	-	2	3	3	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: network architecture - protocol implementation issues - network design. Reference models- The OSI Reference Model- the TCP/IP Model - A Comparison of the OSI and TCP/IP ModelsDatalink Layer- Ethernet, Token ring, wireless LANs-Issues with data link Protocols-Encoding framingand error detection and correction-sliding window Protocol-Medium access control

Network layer: network layer design issues - Routing algorithms - Congestion control algorithms – Internetworking - The network layer in the internet - Internet Protocol (IP) - Unicast, multicast, and inter domain routing

Transport layer: Elements of transport protocol - Congestion control – The Internet's Transmission Control Protocol (TCP) - Remote Procedure Call (RPC) – Implementation semantics of RPC – BSD sockets - client- server applications

Application layer: Domain name server – Simple Mail Transfer Protocol – File Transfer Protocol -World wide web - Hypertext transfer protocol -Presentation formatting and data compression- Introduction to Network security - Web Services architectures for developing new applicationprotocols.

Learning Resources:

Text Books:

1. **Larry L Peterson, Bruce S Davis**, Computer Networks, Elsevier, 2012, 5th Edition.
2. **Andrew S. Tanenbaum, David J Wetherall**, Computer Networks, Pearson Edu, 2010, 5th Edition.

CD1307 **3-0-0 (3)**

Machine Learning

Pre-Requisites:

Course Outcomes:

CO-1	Understand instance-based learning algorithms.
CO-2	Design neural network to solve classification and function approximation problems.
CO-3	Build optimal classifiers using genetic algorithms.
CO-4	Design convolutional networks to solve classification problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	1	2	2	-	1	–	–	1	–	-	2	1	2	2
CO-2	2	1	2	2	2	-	1	-	–	1	–	-	2	2	2	2
CO-3	2	1	1	2	2	-	1	-	–	1	-	-	2	2	2	2
CO-4	2	2	2	2	2	1	2	-	–	1	1	-	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction – Well defined learning problems, Designing a Learning System, Issues in Machine Learning; - The Concept Learning Task - General-to-specific ordering of hypotheses, Find-S, List then eliminate algorithm, Candidate elimination algorithm, Inductive bias - Decision Tree Learning - Decision tree learning algorithm-Inductive bias- Issues in Decision tree learning; - Artificial Neural Networks – Perceptrons, Gradient descent and the Delta rule, Adaline, Multilayer networks, Derivation of backpropagation rule- Backpropagation Algorithm- Convergence, Generalization; – Evaluating Hypotheses – Estimating Hypotheses Accuracy, Basics of sampling Theory, Comparing Learning Algorithms; - Bayesian Learning – Bayes theorem, Concept learning, Bayes Optimal Classifier, Naïve Bayes classifier, Bayesian belief networks, EM algorithm; - Computational Learning Theory – Sample Complexity for Finite Hypothesis spaces, Sample Complexity for Infinite Hypothesis spaces, The Mistake Bound Model of Learning; - Instance-Based Learning – k-Nearest Neighbour Learning, Locally Weighted Regression, Radial basis function networks, Case-based learning - Genetic Algorithms – an illustrative example, Hypothesis space search, Genetic Programming, Models of Evolution and Learning; Reinforcement Learning - The Learning Task, Q Learning, Support vector Machines, Deep learning networks – Deep Feedforward Networks – Regularization for Deep Learning – Optimization for Training Deep Models – Convolutional Network

Learning Resources:

Text Books:

1. **Tom.M.Mitchell**, "Machine Learning", McGraw Hill International Edition, 1997
2. **C Bishop**, "Pattern Recognition and Machine Learning", Springer, 2006.

Reference Books:

1. **Ian Goodfellow, Yoshua Bengio, AaronCourville**, "Deep Learning", The MIT Press Cambridge, Massachusetts, London, England, 2016.

CD1381 **1-0-0 (0.5)**

Fractal Course I

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Mathematics and Computing.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content.
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	-	-	-	-	-	-	-	-	-	3	2	2	2
CO-2	-	-	-	2	2	3	3	-	-	-	-	-	2	3	3	2
CO-3	-	-	3	2	2	-	-	-	-	-	-	-	3	3	1	2
CO-4	-	-	-	-	-	-	-	-	1	3	-	2	3	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the in Mathematics and Computing field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Mathematics and Computing related Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. Content: Topics covering current practices, case studies, technological advancements, and future trends.
c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts.

CD1309 **0-1-2 (2)**

Computer Networks Laboratory

Pre-Requisites:

Course Outcomes:

CO-1	Implement error detection and correction.
CO-2	Develop programs for client-server applications.
CO-3	Implement Chat servers.
CO-4	Perform packet sniffing and analyze packets in network traffic.
CO-5	Implement error detecting and correcting codes.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	1	2	-	-	-	-	-	-	-	-	2	-	-	-
CO-2	2	3	2	2	1	1	-	2	-	-	-	1	1	2	-	2
CO-3	3	2	3	-	2	-	2	-	-	-	-	2	2	2	-	-
CO-4	2	3	2	2	1	1	-	2	-	-	-	1	1	2	-	2
CO-5	1	1	1	2	-	-	-	-	-	-	-	-	2	-	-	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Programs to implement error detection and correction.
2. Client-Server applications using inter process communication mechanisms a) FIFO b) Message queues c) Shared memory.
3. Connection-oriented Client-Server applications based on BSD sockets.
4. Connectionless Client-Server applications.
5. Implementation of Chat servers and mail Servers.
6. Implementation of routing algorithms.
7. Programs using Remote Procedure Call (RPC).
8. Client-Server applications based on Raw Sockets, IP Spoofing.
9. Implementation of application layer protocols.
10. Datalink layer Access, Packet Sniffing.

Learning Resources:

Text Books:

1. **W. Richard Stevens**, UNIX Network Programming, Volume 1, Second Edition: Networking APIs: Sockets and XTI, Prentice Hall, 1998
2. **W. Richard Stevens**, UNIX Network Programming, Volume 2, Second Edition: Interprocess Communications, Prentice Hall, 1999.

Reference Books:

1. **W. Richard Stevens, Stephen Rago**, Advanced Programming in the UNIX Environment, Pearson Education, 2013, third edition.

CD1311 **0-1-2 (2)**

Machine Learning Laboratory

Pre-Requisites:

Course Outcomes:

CO-1	Design and implement algorithm using least means square learning rule to play checkers game.
CO-2	Design a classifier using Genetic Algorithm.
CO-3	Apply supervised learning using perceptron.
CO-4	Design and implement Convolutional Networks to solve classification problem.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	1	2	2	-	1	–	–	1	–	–	2	1	2	1
CO-2	2	1	2	2	2	-	1	-	–	1	–	–	2	1	2	2
CO-3	2	1	1	2	2	-	1	-	–	1	-	–	1	1	1	1
CO-4	2	2	2	2	2	1	2	-	–	1	1	–	2	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Design and implement machine learning algorithm using least means square learning rule to play checkers game. The training experience should be generated by the system playing game with itself.
2. Implement a genetic algorithm program to successfully classify examples in the restaurant domain problem. Data for RESTAURANT domain given in this table.

Example	Friday	Patrons	Price	Rain	Res	Est	Type	Will Wait
X1	No	Some	High	No	Yes	0-10	French	Yes
X2	No	Full	Low	No	No	30-60	Thai	No
X3	No	Some	Low	No	No	0-10	Burger	Yes
X4	Yes	Full	Low	Yes	No	10-30	Thai	Yes
X5	Yes	Full	High	No	Yes	>60	French	No
X6	No	Some	Med	Yes	Yes	0-10	Italian	Yes
X7	No	None	Low	Yes	No	0-10	Burger	No
X8	No	Some	Med	Yes	Yes	0-10	Thai	Yes
X9	Yes	Full	Low	Yes	No	>60	Burger	No
X10	Yes	Full	High	No	Yes	10-30	Italian	No
X11	No	None	Low	No	No	0-10	Thai	No
X12	Yes	Full	Low	No	No	30-60	Burger	Yes

==========

Res indicates reservation made and Est means estimated waiting time to get table, WillWait target attribute indicates whether to wait for table in that restaurant.

3. Design a feed forward neural network using back propagation algorithm to solve and written character recognition problem for A to Z and 0 to 9 letters.
4. Implement perceptron learning algorithm and attempt to solve two input i) AND gate ii) Or Gate iii) EXOR gate problems.
5. Implement Adaline learning algorithm and attempt to solve two input i) AND gate ii) Or Gate iii) EXOR gate problems.
6. Implement a Genetic algorithm to generate solutions for 8-Queens problem.
7. Implement a machine learning program to play 5× 5 Tic tac toe game. The program should use least means square learning rule.
8. Design a Convolutional network for handwritten character recognition problem for A to Z and 0 to 9 digits.

Learning Resources:

Text Books:

1. **Tom.M.Mitchell**, "Machine Learning", McGraw Hill International Edition, 2017.
2. **C Bishop**, "Pattern Recognition and Machine Learning ", Springer, 2006.

Reference Books:

1. **Ian Goodfellow, Yoshua Bengio, AaronCourville**, "Deep Learning", The MIT Press, 2016.

6th Semester

CD1302 **3-0-0 (3)**

Deep Learning

Pre-Requisites:

Course Outcomes:

CO-1	Identify Convolutional Neural Networks models to solve Supervised Learning Problems
CO-2	Design Autoencoders to solve Unsupervised Learning problems
CO-3	Use BiLSTM Networks for time series analysis classification problems.
CO-4	Apply Classical Supervised Tasks for Image Denoising, Segmentation and Object detection problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	3	3	2	3	1	-	-	1	1	1	-	3	2	2	1
CO-2	2	3	3	2	3	1	-	-	1	1	1	-	3	2	3	2
CO-3	3	2	2	3	3	2	-	-	1	1	1	-	2	2	2	1
CO-4	3	2	2	3	3	2	-	-	1	1	1	-	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Biological Neurons, Artificial Neural Networks, McCulloch Pitts Neuron, Learning processes, Perceptron, Perceptron convergence theorem, XOR problem, Multilayer perceptron, Back Propagation Learning, Activation functions, loss functions, Radial Basis Functions. Introduction to Self Organizing Maps;

Optimizers: Gradient Descent (GD), Batch Optimization, Momentum Based GD, Stochastic GD, AdaGrad, RMSProp, Adam; Sequence to sequence models, LSTM, BiLSTM, BERT, SciBERT, BioBERT for NLP Applications; Convolutional Neural Network, Building blocks of CNN, Transfer Learning;

Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Dropout;

Autoencoders : Unsupervised Learning with Deep Network, Autoencoders, Stacked, Sparse, Denoising Autoencoders, Variational Autoencoders; Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, DensenNet, InceptionNets, SqueezNet, MobileNet, NasNet, HRnet Models; Classical Supervised Tasks with Deep Learning, Segmentation: ResUnet, SegNet, Mask RCNN models,

Object Localization: Fast RCNN, Faster RCNN, SSD with Applications; Attention Mechanism, Attention Models in Vision; Image Captioning, Visual QA, Visual Dialog, Transformer, Generative Adversarial Network on Image, CycleGANs, Progressive GANs, StackGANs, Unet GAN, vision and NLP Applications.

Learning Resources:

Text Books:

1. **Ian Goodfelllow, Yoshua Benjio, Aaron Courville,** Deep Learning, The MIT Press, 2016.
2. **Christopher Bishop,** Pattern Recognition and Machine Learning, Springer, 2006.

Reference Books:

1. **Simon Haykin**, Neural Networks, A Comprehensive Foundation, Addison Wesley Longman, 2001, 2nd Edition.

CD1304 **3-0-0 (3)**

Parallel and Distributed Computing

Pre-Requisites:

Course Outcomes:

CO-1	Design and analyze the parallel algorithms for real world problems and implement them on available parallel computer systems.
CO-2	Optimize the performance of a parallel program to suit a particular platform.
CO-3	Design algorithms suited for Multicore processor systems using OpenCL, OpenMP, Threading techniques.
CO-4	Analyze the communication overhead of interconnection networks and modify the algorithms to meet the requirements.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	3	2	2	–	–	–	–	–	–	3	2	2	2
CO-2	3	2	3	3	2	2	–	–	–	–	–	–	2	2	-	3
CO-3	3	3	3	2	2	2	–	–	–	–	–	–	3	3	-	2
CO-4	2	3	3	2	2	2	–	–	–	–	–	–	2	3	-	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Control structure, Interconnection networks, communication costs of parallel platforms, Routing mechanisms for interconnection networks, mapping techniques.

Basic communication operations: Meaning of all-to-all, all-reduce, scatter, and gather, circular shift and splitting routing messages in parts.

Analytical modeling of parallel programs: Sources of overhead, performance metrics, the effect of granularity on performance, scalability of parallel systems, minimum execution time, minimum cost-optimal execution time, asymptotic analysis of parallel programs.

Programming using message passing paradigm: Principles, building blocks, MPI, Topologies and embedding, Overlapping communication and computation, collective communication operations, Groups and communicators.

Programming shared address space platforms: Threads, POSIX threads, Synchronization primitives, attributes of threads, mutex and condition variables, Composite synchronization constructs, OpenMP Threading Building blocks; An Overview of Memory Allocators, An overview of Intel Threading building blocks.

GPU Programming: An Overview of Brief History of GPUs; An Overview of GPU Programming; An Overview of GPU Memory Hierarchy Features; Introduction to Heterogeneous Computing – OpenCL; The OpenCL Kernel, The OpenCL Memory Model, The OpenCL Execution Model; OpenCL Platform and Devices; OpenCL Execution Environment, An Overview of OpenCL API; Heterogeneous Programming in OpenCL An Overview of CUDA enabled NVIDIA GPUs, Introduction to CUDA C, Parallel Programming in CUDA C

Basic parallel algorithms: Prefix sums, Tree traversal algorithms, basic operations (insertion deletion and search) on trees, merging, maximum, graph colouring, list ranking, Planar geometry and String algorithms

Dense Matrix Algorithms: Matrix vector multiplication, matrix-matrix multiplication, solving system of linear equations,

Sorting: Sorting networks, Bubble sort, Quick sort, Bucket sort and other sorting algorithms

Graph algorithms: Minimum spanning tree, single source shortest paths, all-pairs shortest paths, Transitive closure, connected components, algorithms for sparse graphs.

Search Algorithms for Discrete Optimization Problems: Definitions and Examples, Sequential Search Algorithms, Search Overhead Factor, Parallel Depth-First Search, Parallel Best-First Search, Speedup Anomalies in Parallel Search Algorithms

Fast Fourier Transform: The Serial Algorithm, The Binary-Exchange Algorithm, The Transpose Algorithm

Learning Resources:

Text Books:

1. **Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar**, "Introduction to Parallel Computing", Second Edition Pearson Education, 2007.
2. **Michael J. Quinn**, "Parallel Programming in C with MPI and OpenMP", McGraw-Hill International Editions, Computer Science Series, 2004.
3. **Benedict R Gaster, Lee Howes, David R Kaeli, Perhaad Mistry, Dana Schaa**, Heterogeneous Computing with OpenCL, McGraw-Hill, Inc. Newyork , 2011
4. **Jason Sanders, Edward Kandrot**, CUDA By Example – An Introduction to General-Purpose GPU Programming, Addison Wesley, 2011.
5. **Joseph Jaja**, "An Introduction to Parallel Algorithms", Addison-Wesley, 1992.

Reference Books:

1. **S G Akl**, The Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989.

CD1306 **0-1-4 (3)**

Product Development

Pre-Requisites: CD1102

Course Outcomes:

CO-1	Express Product Design Ideas using 2D or 3D sketches, diagrams, etc
CO-2	Model the components with geometric (engineering) specifications and appropriate materials.
CO-3	Develop a prototype of the product.
CO-4	Evaluate the entire product.
CO-5	Improve the product based on testing with user feedback.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–	–
CO-2	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–	–
CO-3	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–	–
CO-4	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–	–
CO-5	–	–	2	3	3	3	2	2	3	3	2	3	3	2	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Design Thinking Process for Product Development: Review of the five-step design thinking process of Empathize, Define, Innovate, Prototype, and Test.

Project Selection: Identification of the problem through empathy, formulate and ideate to solve the problem.

Product Development

Sketching: 2D and 3D sketching: Students will sketch the concept on drawing sheets/ digital screens. The drawings will contain the specifications of the geometric form.

3D Modelling: Develop the 3D model features, including free-form surfaces, final product design specifications, Parametric design.

Physical Component Development: Development of components: fabrication of actual components of the product using the materials and tools available in the lab, Iterations.

Iterative improvement of the product and Report writing: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review and report writing.

Learning Resources:

Text Books:

1. **Sullivan,** The design studio method: creative problem solving with UX sketching, Brian, Focal Press, 2016.
2. **G. Verma**, Autodesk Fusion 360 Black Book, CADACAMCAE Works, 2021, 2nd edition.

Online Resources:

1. Self-Paced Tutorials https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID1C665B4D- 7BF7-4FDF-98B0-AA7EE12B5AC2

CD1382 **1-0-0 (0.5)**

Fractal Course II

Pre-Requisites: None

Course Outcomes:

CO-1	Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in Mathematics and Computing.
CO-2	Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques.
CO-3	Apply learned concepts to solve focused and practical engineering problems related to the course content.
CO-4	Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	-	-	-	-	-	-	-	-	-	3	2	2	2
CO-2	-	-	-	2	2	3	3	-	-	-	-	-	2	3	3	2
CO-3	-	-	3	2	2	-	-	-	-	-	-	-	3	3	1	2
CO-4	-	-	-	-	-	-	-	-	1	3	-	2	3	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the in Mathematics and Computing field and enhancing their readiness for professional careers.

a. Structure: Lectures delivered by an expert from the Mathematics and Computing related Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. Content: Topics covering current practices, case studies, technological advancements, and future trends.
c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

1. Course material and any learning resources suggested by the experts.

CD1308 **0-1-2 (2)**

Deep Learning Laboratory

Pre-Requisites:

Course Outcomes:

CO-1	Implement Multilayer Feed Backward Neural network on MNIT digits dataset
CO-2	Build RNN, LSTM, BiLSTM Networks for time series analysis classification problems.
CO-3	Design Autoencoders to solve Unsupervised Learning problems
CO-4	Implement Classical Supervised Tasks for Image Denoising, Segmentation and Object detection problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	1	1	1	1	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	1	1	2		2	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Implement perceptron learning algorithm and attempt to solve two input i) AND gate ii) Or Gate iii) EXOR gate problems.
2. Design and implement a perceptron learning algorithm and attempt to solve XOR problem
3. Implement a Multilayer Feed Backward Neural network algorithm on MNIT digits dataset.
4. Build your own Recurrent networks and Long short-term memory networks on IMDB movie reviews classification data.
5. Design and implement a BiLSTM and BERT on given a product review dataset to classify the review rating from 1 to 5 classes
6. Design and implement Autoencoders for credit card fraud detection.
7. Design and implement a Convolutional Neural Network for image classification on the Fashion MNIST dataset.
8. Implement a VGG19 model for image classification with and without Transfer Learning on Grocery dataset.
9. Implement a U-Net convolutional neural network model on segmentation of electron microscopic (EM) images of the brain dataset.
10. Implement a FRCNN algorithm for object detection on small object dataset.

Learning Resources:

Text Books:

1. **Ian Goodfelllow, Yoshua Benjio, Aaron Courville,** Deep Learning, The MIT Press, 2016.
2. **Christopher Bishop,** Pattern Recognition and Machine Learning, Springer, 2006.

Reference Books:

1. **Simon Haykin**, Neural Networks, A Comprehensive Foundation, 2nd Edition, Addison Wesley Longman, 2001.

CD1310 **0-1-2 (2)**

Parallel and Distributed Computing Laboratory

Pre-Requisites:

Course Outcomes:

CO-1	Implementation of the parallel algorithms for real world problems on available parallel computer systems.
CO-2	Optimize the performance of a parallel program to suit a particular platform.
CO-3	Implementation of algorithms suited for Multicore processor systems using OpenCL, OpenMP, Threading techniques.
CO-4	Parallel Implementations and Analysis of the communication overhead of interconnection networks and modify the algorithms to meet the requirements.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	3	2	2	–	–	–	–	–	–	3	2	2	2
CO-2	3	2	3	3	2	2	–	–	–	–	–	–	2	2	-	3
CO-3	3	3	3	2	2	2	–	–	–	–	–	–	3	3	-	2
CO-4	2	3	3	2	2	2	–	–	–	–	–	–	2	3	-	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

OpenMP, MPI, CUDA/OpenCL programs for matrix operations, sorting, graph algorithms, searching and discrete optimization problems and fast Fourier transform algorithms.

Learning Resources:

Text Books:

1. **Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar**, "Introduction to Parallel Computing", Second Edition Pearson Education – 2007
2. **Michael J. Quinn** (2004), "Parallel Programming in C with MPI and OpenMP", McGraw-Hill International Editions, Computer Science Series,

Reference Books:

1. **Joseph Jaja**, "An Introduction to Parallel Algorithms", Addison-Wesley, 1992

7th Semester

MS1262 **3-0-0 (3)**

Business Essentials for Engineers

Pre-Requisites:

Course Outcomes:

CO-1	Understand the basic concepts of management and its functions.
CO-2	Apply the functions of management for taking effective decisions.
CO-3	Analyze factors influencing management in competitive business environment.
CO-4	Identify business opportunities and challenges.
CO-5	Integrate functions of management for building a better organization.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	3	–	3	3	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	3	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	1	–	3	3	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	1	–	2	2	–	–	–	–
CO-5	–	–	–	–	–	–	–	–	1	–	1	2	–	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: The evolution of management theory, Business functions and their roles, Organizations and types, Levels of management, Types of markets and pillars of management- planning, organizing, leading and controlling.

People Management: Catalysts for organizational performance – Motivation & Leadership, Organization culture & Change, Human resource functions in a dynamic business environment and evolving dynamics in Industrial Relations.

Marketing Management: Nature and scope of marketing, Company's orientation towards market place, Importance of marketing concept, Marketing environment, 4p's of marketing, market segmentation, target market selection and positioning.

Financial Management: Financial accounting, Financial statements and analysis for decisions, Financial planning, Capital, Working capital, Capital structure and Sources of corporate finance, Investment decisions.

Project Management: Project screening and Selection, Techniques, Structuring concepts and Tools (WBS, OBS, and LRC, RACE). Project life cycle analysis. Appraisal of a project, Project Planning: Techniques, CPM, PERT-GAN - Time Cost Trade-off and Crashing Procedure, Project Monitoring: Monitoring Techniques and time control System, EVA Analysis

Quality & Strategy: Quality, Principles, Quality Awards, Standards of Quality culture, Quality metrics programs, Strategy, Vision and Mission, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Competitive advantage - Value chain analysis & Resource based view.

Learning Resources:

Text Books:

1. **Ronald J. Ebert, Ricky W. Griffin**, Business Essentials, Pearson, 2019, 12th Edition

2. **Harold Koontz, Heinz Weihrich, Mark V. Cannice**, Essentials of Management, McGraw hill, 2020, 11th Edition.

Reference Books:

1. **G. Shainesh Philip Kotler, Kevin lane Keller, Alexander Chernev, Jagdish N. Sheth**, Marketing Management, Pearson, 2022, 16th Edition
2. **Dessler, G., & Varkkey, B**, Human Resource Management, Pearson Education, 2024, 17th Edition
3. **Prasanna Chandra**, Financial Management: Theory & Practice, Mc Graw Hill, 2022, 11th Edition
4. **Poornima M Charantimath**, Total Quality Management, Pearson, 2022, 4th Edition
5. **IM Pandey**, Financial Management, Vikas Publications, 2021, 12th Edition
6. **Jack R. Meredith, Mantel**, Project Management - A Managerial Approach, John Wiley, 2021,11th Edition

Other Suggested Readings:

1. https://nptel.ac.in/courses/110106050
2. https://nptel.ac.in/courses/110105146
3. https://nptel.ac.in/courses/110105069
4. https://nptel.ac.in/courses/110104068
5. https://ocw.mit.edu/courses/15-535-business-analysis-using-financial-statements-spring-2003/
6. https://ocw.mit.edu/courses/15-810-marketing-management-fall-2010/

CD1401 **0-1-2 (2)**

Agentic AI Laboratory

Pre-Requisites:

Course Outcomes:

CO-1	Learn various agent models.
CO-2	Learn and implement various searching techniques on live examples.
CO-3	Create and design knowledge-based agents.
CO-4	Create and design agents to work in uncertain environments.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	2	2	-	-	2	-	-	-	3	3	3	1
CO-2	3	3	3	3	2	2	-	-	2	-	-	3	3	3	3	2
CO-3	3	3	3	3	2	2	-	-	2	-	-	3	3	3	3	2
CO-4	3	3	3	3	2	3	-	-	2	-	-	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. Explore open source LLMs with LLM studio
2. Prompting LLMs with prompt engineering
3. Customizing GPT and adding custom actions
4. Extending an assistant's knowledge
5. Publishing a GPT
6. Exploring multi agent systems with AutoGen studio
7. Group chat with agents
8. Building an agent crew with CrewAI
9. Adding semantic kernels to LLM API calls
10. Building autonomous agents
11. Constructing RAG with LangChain and applying RAG to build agent knowledge
12. Exploring prompt flow API

Learning Resources:

Text Books:

1. **Micheal Lanham**, AI Agents in Action, Manning Publishers, 2025
2. **Ted Winston**, Mastering Agentic AI: A Practical Guide to Building Self-Directed AI Systems that Think, Learn, and Act Independently, Independently published, 2025
3. **Taylor Royce**, Agentic AI: Harnessing the power of autonomous systems in the modern workplace, Independently published, 2024

CD1489 **2-0-0 (2)**

Seminar and Technical Writing

Pre-Requisites: None

Course Outcomes:

CO-1	Consolidate ideas based on expert talks attended.
CO-2	Prepare a well-organized report employing elements of critical thinking and technical writing.
CO-3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	–	2	–	–	3	3	–	2	3	–	3	–	–	–	–
CO-2	2	–	2	–	–	3	3	–	2	3	–	3	–	–	–	–
CO-3	2	–	2	–	–	3	3	–	2	3	–	3	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	15 Marks
II	List of lectures attended	20 Marks
III	Report	25 Marks
IV	Presentation	25 Marks
V	Response to questions	15 Marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

CD1491 **2-0-0 (2)**

Short Term Industrial / Epics / Research Experience

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world problems, gaining practical experience.
CO-2	Plan, manage and execute the work with ethical consideration.
CO-3	Review the social and environmental impact of the work.
CO-4	Communicate the learnings through report and presentation.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3	–	–	–	–	–	–	3	–	–	–	–
CO-2	2	2	2	2	2	–	–	3	3	–	3	3	–	–	–	–
CO-3	–	–	–	–	–	3	3	–	–	–	–	3	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	–	3	–	3	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Relevance of the area of work	15 Marks
II	Performance of the Task	25 Marks
III	Crucial learnings from the work	25 Marks
IV	Report Preparation	20 Marks
V	Presentation and Response to questions	15 Marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

CD1495 **2-0-0 (2)**

Minor Project

Pre-Requisites: None

Course Outcomes:

CO-1	Apply engineering principles to real-world projects.
CO-2	Plan and monitor project tasks individually or as a team.
CO-3	Demonstrate practical experience in project execution.
CO-4	Communicate project findings clearly through reports and presentations.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	3	3	3	–	–	–	2	1	–	3	–	–	–	–
CO-2	2	2	2	2	2	–	–	–	3	2	3	3	–	–	–	–
CO-3	2	2	2	2	2	–	–	–	3	2	3	3	–	–	–	–
CO-4	1	1	1	1	1	–	–	–	3	3	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Identification of Problem Domain	15 Marks
II	Study of Existing Systems and establishing clear objectives	20 Marks
III	Planning of project and work distribution within the team	25 Marks
IV	Proper Documentation and Technical Writing	25 Marks
V	Presentation and Response to questions	15 Marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X	X	
IV				X
V				X

8th Semester

CD1498

0-0-0 (6)

Major Project

Pre-Requisites: None

Course Outcomes:

CO-1	Identify a domain specific and contemporary topic.
CO-2	Review literature to identify gaps and define objectives & scope of the work.
CO-3	Develop a prototype/model, experimental set-up or software systems to meet the objectives.
CO-4	Analyze the results to draw valid conclusions.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	–	–	2	1	–	1	3	1	1	2	3	–	2	–
CO-2	2	2	–	–	1	2	1	1	2	2	–	3	1	–	2	–
CO-3	2	2	3	3	3	2	2	2	2	1	3	2	2	3	2	2
CO-4	2	2	–	3	3	–	–	–	2	2	–	3	3	–	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The B.Tech. Project work will be evaluated for 100 marks, with the following weightages:

Component	Weightage
Periodic evaluation by Guide	40 marks
Mid-term review	20 marks
End Semester viva-voce examination	40 marks
Total	100 marks

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Selection of Topic	10 Marks
II	Literature Survey	15 Marks
III	Objectives and Solution Methodology	15 Marks
IV	Performance of the Task and clarity on the work	30 Marks
V	Report Preparation	15 Marks
VI	Presentation and Response to questions	15 Marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO1	CO2	CO3	CO4
I	X			
II		X		
III		X		
IV			X	
V				X
VI				X

Refer to B.Tech. – Regulations for any further information regarding Mid-term review, End Sem evaluation, Template for report preparation and plagiarism.

Professional Electives

MA1325 **3-0-0 (3)**

Multivariate Calculus and Measure Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Identify the class of measurable sets.
CO-2	Derive properties of Lebesgue measurable sets and functions.
CO-3	Understand the contraction principle.
CO-4	Understand implicit function theorem.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	3	1	1	–	–	–	–	–	–	–	–	–	–	–	2
CO-2	1	2	3	–	2	–	–	–	–	–	–	–	2	1	2	3
CO-3	2	2	1	–	–	–	3	–	–	–	–	–	–	–	2	2
CO-4	2	2	1	–	–	–	3	–	–	–	–	–	–	–	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Multivariable Differential Calculus: Functions of several variables, limits, continuity, differentiability, gradient, directional derivatives, chain rule, Taylor's theorem, maxima & minima and method of Lagrange multipliers.

Multivariable Integral Calculus: Double and triple integrals, Jacobian and change of variables formula, Applications to Area, Volume, Surface area and surface integrals, Vector fields, divergence and curl, line integrals, Tangents & Normals, Parametrization of curves and surfaces, Green, Gauss, Stokes theorems and applications.

Lebesgue Measure: Outer measure, measurable sets, a non-measurable set, example of measurable set which is not a Borel set, Lebesgue measure and its properties, measurable functions.

Learning Resources:

Text Books:

1. **G.B. Thomas, R.L. Finney, M.D. Weir and F.R. Giordano,** Thomas' Calculus, Pearson, 2003.
2. **H. L. Royden,** Real Analysis, Pearson, 2003, Third Edition.

Reference Books:

1. **W. Rudin,** Real and Complex Analysis, Tata McGraw-Hill Edition, 2006, Third edition.

MA1361 **3-0-0 (3)**

Digital Systems and Microcontrollers

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of Number system and Boolean algebra
CO-2	design of combinational and sequential logic circuits
CO-3	Understand architecture and instruction set of 8051 microcontrollers
CO-4	Develop various applications by interfacing various modules to 8051

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	2	–	3	2	–	–	1	2
CO-2	–	–	–	–	–	–	–	–	2	–	3	2	–	–	1	2
CO-3	–	–	–	–	–	–	–	–	2	–	3	2	–	–	2	2
CO-4	–	–	–	–	–	–	–	–	2	–	3	2	–	–	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Number Systems and Boolean Algebra: Decimal, binary, octal, hexadecimal number system and conversion , binary weighted codes, signed numbers, 1s and 2s complement codes, Binary arithmetic Binary logic functions, Boolean laws, truth tables, associative and distributive properties, DeMorgans theorems, realization of switching functions using logic gates

Combinational Logic: Switching equations, canonical logic forms, sum of product & product of sums, Karnaugh maps, two, three and four variable Karnaugh maps, simplification of expressions, Quine- McCluskey minimization technique, mixed logic combinational circuits, multiple output functions. Introduction to combinational circuits, code conversions, decoder, encoder, priority encoder, multiplexers as function generators, binary adder, substractor, BCD adder, Binary comparator, arithmetic logic units.

Sequential Logic: Sequential circuits, flip-flops, clocked and edge triggered flipflops, timing specifications, asynchronous and synchronous counters, counter design with state equations, Registers, serial in serial out shift registers.

Introduction to 8051 Microcontroller: Introduction to Microprocessor Architecture Introduction and evolution of Microprocessors, Overview of 8051 Micro Controller– Architecture– Register set–I/O ports and Memory Organization– Interrupts–Timers and Counters–Serial Communication, assembly programming.

Interfacing and Applications of 8051: LEDs and push buttons Interfacing, Relays and Latch connections, seven segment display interfacing, A/D and D/A converter interfacing.

Learning Resources:

Text Books:

1. **M. Morris Mano**, Digital Logic and Computer Design, Pearson Education, Jan 2004.
2. **Kenneth. J. Ayala.** The 8051 microcontroller 3rd Edition, Cengage Learning, 2010

Reference Books

1. **John F. Wakerly**, “Digital Design Principles & Practices” Prentice hall, 3rd edition 2000.
2. **Muhammad Ali Majid,** Janice Gillespie Majid and Rollin D McKinlay, “The 8051 microcontroller and Embedded systems”, Pearson, 2nd Edition.
3. **Ajay. V. Deshmukh**, “Microcontrollers and applications”, Tata McGraw Hill, 2005.

EC1362 **3-0-0 (3)**

Principles of Signals and Systems

Pre-Requisites: None

Course Outcomes:

CO-1	Classify signals as continuous and discrete time
CO-2	Analyze the spectral characteristics of continuous-time signals using Fourier analysis
CO-3	Classify systems based on their properties and determine the response of LTI system using convolution
CO-4	Analyze the spectral characteristics of discrete-time signals using Fourier analysis

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	–	–	–	–	–	–	–	2	–	3	2	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	2	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	2	–	3	2	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	2	–	3	2	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Linear time invariant systems: Discrete Time LTI Systems, Continuous Time LTI Systems, properties of LTI Systems, causal LTI Systems described by Difference equations.

Fourier series representation of periodic signals: Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

Continuous time Fourier transform: Representation of a periodic Signals by continuous FT, FT of periodic signals, convolution and multiplication property of continuous FT, systems characterized by Linear Constant Coefficient Differential Equations.

Time and frequency characterization of signals and systems: Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time domain and Frequency domain aspects of ideal and non-ideal filters.

Discrete time Fourier transform and discrete Fourier transform: Properties of Discrete time Fourier transform and discrete Fourier transform: convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations.

Learning Resources:

Text Books:

1. **Alan Oppenheim, Alan Willsky, S. Nawab,** Signals and Systems, PHI, 2000, 2nd Edition.

Reference Books:

1. **Robert A. Gable, Richard A. Roberts**, Signals and Linear Systems, John Wiley, 1995, 3rd Edition.
2. **John G. Proakis, Dimitris G. Manolakis**, Digital Signal Processing, Principles, Algorithms, and Applications, PHI, 2007, 4th Edition.

Other Suggested Readings:

https://nptel.ac.in/courses/108102042

CD1321 **3-0-0 (3)**

Scalable Systems for Data Science

Pre-Requisites: None

Course Outcomes:

CO-1	Understand types of Big Data, Design goals of Big Data platforms, identify where in the systems landscape these platforms fall
CO-2	Practice distributed programming models for Big Data, including Map Reduce, Stream processing and Graph processing
CO-3	Optimize runtime systems for Big Data platforms on commodity clusters and Clouds
CO-4	Scaling data science algorithms and analytics using Big Data platforms

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1
CO-2	–	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1
CO-3	3	–	–	–	3	3	–	3	–	–	–	–	1	2	1	2
CO-4	1	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1
CO-5	1	2	3	3												

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

The design of distributed program models and abstractions, such as MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity and linked datasets, and for storing and querying over NoSQL datasets. The approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions.
Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner.

Learning Resources:

Text Books:

1. **Jimmy Lin and Chris Dyer**, Data-Intensive Text Processing with MapReduce, 1st Edition, Morgan & Claypool Publishers, 2010
2. **Jure Leskovec, Anand Rajaraman and Jeff Ullman**, Mining of Massive Datasets, 2nd Edition (v2.1), 2014.
3. Current literature and online documentation

CD1323 **3-0-0 (3)**

Algorithmic Algebra

Pre-Requisites: CD1201

Course Outcomes:

CO-1	Analyze the structure of finite fields
CO-2	Test irreducibility of polynomials
CO-3	Factorize polynomials over finite fields
CO-4	Understand the group structure on elliptic curves over finite fields
CO-5	Evaluate pairing on elliptic curves using Miller's Algorithm

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	-	3	-	-	-	-	-	-	-	3	1	-	3
CO-2	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-3	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-4	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-5	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Arithmetic of Finite Fields: Representation of Finite Fields (Polynomial-Basis Representation, Choice of the Defining Polynomial), Implementation of Finite Field Arithmetic (Representation of Elements, Polynomial Arithmetic, Polynomial GCD and Euclidean Inverse), Fermat's Little Theorem for Finite Fields, Multiplicative Orders of Elements in Finite Fields, Normal Elements, Minimal Polynomials, Alternative Representations of Finite Fields (Representation with Respect to Arbitrary Bases, Normal and Optimal Normal Bases, Discrete-Log Representation, Representation with Towers of Extensions), Computing Isomorphisms among Representations.

Arithmetic of Polynomials: Polynomials over Finite Fields (Polynomial Arithmetic, Irreducible Polynomials over Finite Fields, Testing Irreducibility of Polynomials), Finding Roots of Polynomials over Finite Fields (Algorithm for Fields of Odd Characteristics, Algorithm for Fields of Characteristic Two), Factoring Polynomials over Finite Fields(Square Free Factorization, Distinct-Degree Factorization, Equal-Degree Factorization), Properties of Polynomials with Integer Coefficients(Relation with Polynomials with Rational Coefficients, Height, Resultant, and Discriminant, Hensel Lifting), Factoring Polynomials with Integer Coefficients (Berlekamp's Factoring Algorithm, Basis Reduction in Lattices, LLL Factoring Algorithm).

Arithmetic of Elliptic Curves: Elliptic-Curve Group, Elliptic Curves over Finite Fields, Theory of Algebraic Curves, Polynomial and Rational Functions on Curves, Rational Maps and Endomorphisms on Elliptic Curves, Divisors, Pairing on Elliptic Curves (Weil Pairing, Miller's Algorithm, Tate Pairing).

Learning Resources:

Text Books:

1. **Abhijit Das**: Computational Number Theory (2013).
2. **Joachim von Zur Gathen and Jurgen Gerhard**: Modern Computer Algebra (3/e, 2013).

Reference Books:

1. **David S. Dummit & Richard M. Foote**: Abstract Algebra, Wiley, 2004, Third Edition.
2. **Victor Shoup**: A Computational Introduction to Number Theory and Algebra (2008).

CD1322 **3-0-0 (3)**

Computational Number Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Learn modular arithmetic.
CO-2	Know the basic arithmetic of finite fields
CO-3	Test the primality of integers
CO-4	Factor integers
CO-5	Compute discrete logarithms over finite fields

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	-	3	-	-	-	-	-	-	-	3	1	-	3
CO-2	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-3	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-4	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3
CO-5	1	1	1	-	2	-	-	-	-	-	-	-	3	-	-	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Algorithms for integer arithmetic: Divisibility, gcd, prime number theorem, modular arithmetic, modular exponentiation, congruence, Euler's phi function, Fermat's little theorem, Chinese remainder theorem (CRT), Hensel lifting, orders and primitive roots, quadratic residues, modular square roots and continued fractions. Introduction to PARI/GP calculator to carry out number theory computations.

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.

Algorithms for polynomials: Root-finding and factorization.

Primality testing algorithms: Fermat test and Miller-Rabin test.

Integer factoring algorithms: Trial division, Pollard rho method and p-1 method.

Computing discrete logarithms over finite fields: Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method and index calculus methods.

Elliptic curves: The elliptic curve group, elliptic curves over finite fields and elliptic curve method for integer factorisation.

Learning Resources:

Text Books:

1. **Abhijit Das**, Computational number theory, CRC press, 2015.
2. **Victor Shoup**, A Computational Introduction to Number Theory and Algebra: Version 2, Cambridge University Press, 2008. (Available at https://www.shoup.net/ntb/)

Reference Books:

1. **Kenneth H. Rosen**, Elementary Number Theory & Its Applications, Pearson, 2011, Sixth Edition.
2. **Joseph H. Silverman**, The Arithmetic of Elliptic Curves, Springer, 2009, Second Edition.

CD1324 **3-0-0 (3)**

Information and Coding Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Understand Shannon's noisy coding theorem, Shannon capacity and entropy.
CO-2	Analyze the channel performance using information theory.
CO-3	Design of error correcting codes and decoding algorithms.
CO-4	Design of network coding algorithms for communication networks.
CO-5	Analyze coding techniques for data storage, security and compression.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	1	–	–	–	–	–	–	–	–	3	2	–	3
CO-2	3	2	2	1	–	–	–	–	–	–	–	–	3	2	–	3
CO-3	3	2	2	1	–	–	–	–	–	–	–	–	3	2	–	3
CO-4	3	2	2	1	–	–	–	–	–	–	–	–	3	2	–	3
CO-5	3	2	2	2	–	–	–	–	–	–	–	–	3	2	–	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Mathematical Foundation of Information Theory in communication system. Measures of Information- Self information, Shannon's Entropy, joint and conditional entropies, mutual information and their properties. Discrete memoryless channels: channel capacity, fundamental theorem of information theory. Coding Theory: Huffman codes, Shannon-Fano coding, robustness of coding techniques, Information measure-noiseless coding, Error correcting codes: minimum distance principles, Hamming bound, general binary code, group code, linear group code Convolution encoding: algebraic structure, Gilbert bound Threshold decoding: threshold decoding for block codes Cyclic binary codes: BCH codes, generalized BCH code and decoding, optimum codes, concepts of non-cyclic codes. Cryptography with error correcting codes, Security against adversarial errors, security for data networks. Network Coding: Fundamentals of Network Coding: Butterfly networks, graphs and networks. The max-flow min-cut theorem, the multi-source multicast problem, deterministic code design for network coding, randomized network coding application of network coding. Efficient data storage and data compression techniques. Analysis coding techniques for various applications.

Learning Resources:

Text Books:

1. **J. A. Thomas and T. M. Cover**, Elements of information theory, Wiley, 2006.
2. **J. H. van Lint**: Introduction to Coding Theory, Third Edition, Springer, 1998
3. **C. Fragouli and E. Soljanin**: Network Coding Fundamentals, Now Publisher, 2007.

Reference Books:

1. **F. J. MacWilliams and N.J. Sloane**: Theory of Error Correcting Codes, Parts I and II, North-Holland, Amsterdam, 1977.
2. **Tom Richardson, RudigerUrbanke**, Modern Coding Theory, Cambridge University Press, 2008
3. **John b. Anderson and Seshadri Mohan,** Source and Channel Coding: An Algorithm Approach, Springer, 1991.

4. **G. Kabatiansky, E. Krouk and S. Semenov**, Error Correcting Coding and Security for Data Networks, John Wiley & Sons Ltd., 2005
5. **T. Ho and D. S. Lun**, Network Coding: An Introduction, Cambridge University Press, Cambridge, U.K., April 2008.

CD1326 **3-0-0 (3)**

Applied Statistical Methods

Pre-Requisites: None

Course Outcomes:

CO-1	Able to solve the problems on Correlations & Regressions and ANOVA.
CO-2	Understand the theory of estimation and confidential intervals.
CO-3	Able to apply the theory of sampling to experimental problems.
CO-4	Use the theory of index numbers in various real-world problems.
CO-5	Able to understand the time series.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	2	1	2	1	-	2	1	2	-	-	-	2	1	2
CO-2	3	2	2	1	2	1	1	-	-	2	2	1	-	2	1	2
CO-3	3	3	2	1	2	-	-	2	-	2	2	-	2	2	1	2
CO-4	3	3	2	1	2	1	2	2	2	3	2	2	2	2	1	2
CO-5	3	3	2	1	2	-	-	-	2	-	1	1	2	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Correlations & Regressions- Partial correlation, Multiple correlation, Multiple linear regression

ANOVA-Concepts of statistical design, One-way and two-way analysis of variance techniques. Latin Square Design.

Estimation: Point estimation, Unbiasedness, Consistency, Efficiency, and Sufficiency; Fisher- Neyman factorization theorem, complete sufficient statistics, minimum variance unbiased estimator (MVUE), Cramer
- Rao inequality, Bhattacharya's inequality, Rao–Blackwell theorem. Exponential family, Maximum Likelihood estimation method, method of moments, method of minimum chi-squares, and interval estimation.

Confidence Intervals- CI for means, CI for variances.

Sampling Theory- Basic concepts of sampling from a finite population, sampling versus complete enumeration, simple random sampling, stratified random sampling, cluster sampling, and systematic sampling. Definitions of ratio, product, and regression estimators. The idea of non–sampling errors.

Theory of index numbers- Applications to price and production, link and chain relatives' composition of index numbers, Laspeyre's, Paasche's, Marshall and Edgeworth's, and Fisher's index numbers, chain base index numbers, tests for index numbers, cost of living index numbers and their construction.

Time Series- Concept of different time series components, trend determination, and seasonal fluctuations. Moving averages.

Learning Resources:

Text Books:

1. **Cochran W.G,** Sampling Techniques III Edition, 1988, Wiley.
2. **C.D. Montgomery**, Design and Analysis of Experiments, Wiley & Sons, 1976, New York.

Reference Books:

1. **M.N. Das and N.C.Giri**, Design and Analysis of Experiments, Wiley, Eastern Pvt. Ltd., 1979, New Delhi.
2. **Des Raj and Chandak,** Sampling Theory. Narosa, 1988.
3. **Richard A. Johnson**, Miller & Freund's Probability and Statistics for Engineers, Pearson, 2018, Ninth Edition.

CD1328 **3-0-0 (3)**

Numerical Linear Algebra

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic concepts of linear algebra related to stability, accuracy, etc.,
CO-2	Find the QR factorization of a matrix using Householder transformation and study its applications.
CO-3	Write various algorithms to solve a system of linear equations to understand computational issues.
CO-4	Describe the numerical procedure of the eigenvalue problem.
CO-5	Apply the SVD of a matrix in solving real-life problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	1	-	-	-	1	-	-	-	-	1	3	1	1	2
CO-2	2	2	1	-	-	-	-	-	-	-	-	-	3	1	1	2
CO-3	2	2	2	1	1	-	1	-	-	-	-	-	3	1	2	2
CO-4	3	2	2	2	-	-	1	-	-	-	-	-	2	-	1	-
CO-5	3	2	2	2	-	-	-	-	-	-	-	-	2	-	1	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Review of linear algebra concepts: Vector and Matrix norms and norm-preserving properties of orthogonal matrices; Linear transformations, rank, basis.

Transformations in numerical linear algebra and their applications: Elementary matrices, Householder transformation with applications to LU, QR factorizations, and Hessenberg-reduction. Orthonormal bases and orthogonal projections.

Numerical Solutions of Linear Systems: QR factorizations with growth factors and stability; estimation of the condition numbers; iterative methods: Jacobi and Gauss-Seidel methods and their convergence; Least squares Solutions to Linear Systems: existence and uniqueness, Normal equations; Pseudo Inverse; QR factorization methods for overdetermined systems.

Numerical Matrix Eigenvalue Problems: Gershgorin disk theorem, the Power method, the Inverse Power methods & Rayleigh Quotient Iteration; Basic and Hessenberg QR iterations.

The Singular Value Decomposition: Properties and applications of SVD.

Learning Resources:

Text Books:

1. **Biswa Nath Datta**, Numerical Linear Algebra and Applications, Prentice Hall India/SIAM, 2010/2013, Second Edition.
2. **Carl D. Meyer**, Matrix Analysis and Applied Linear Algebra, SIAM, 2000.

Reference Books:

1. **David Kincaid and Ward Cheney**,Numerical Analysis: Mathematics of Scientific Computing, American Mathematical Society, 2002.
2. **V. Sundarapandian**, Numerical Linear Algebra, Prentice Hall India, 2014.

CD1330 **3-0-0 (3)**

Time Series Analysis and Forecasting

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the concepts of Vector space and inner-product spaces
CO-2	Apply the linear algebra concepts in approximations and matrix decompositions
CO-3	Understand functions of several variables and gradients
CO-4	Apply optimization techniques in real life problems
CO-5	Acquire sound mathematical aspects of computation

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	3	2	2	–	2	–	–	–	–	–	–	–	–	2	2
CO-2	3	–	–	–	3	3	–	2	–	–	–	–	2	2	2	1
CO-3	–	3	2	2	–	2	–	–	–	–	–	–	–	–	2	2
CO-4	3	–	–	–	3	3	–	2	–	–	–	–	2	2	2	1
CO-5	3	2	2	–	3	3	–	2	–	–	–	–	2	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: The Concept of Time Series - Brief History of Time Series Analysis - Objectives of Time Series Analysis - Exploratory Time Series Data Analysis.

Stationary Time Series Models: Backshift Operator, Differencing, and Stationarity Test - Moving Average Models - Autoregressive Models - Autoregressive Moving Average Models - ARMA and ARIMA Modeling and Forecasting.

Nonstationary Time Series Models: The Box-Jenkins Method - SARIMA Model Building - REGARMA Models.

Multivariate Time Series Analysis: Basic Concepts - VARMA Models - VAR Model Building and Analysis- State Space Models and Markov Switching Models - State Space Models and Markov Switching Models.

Nonstationarity and Cointegrations: Stochastic Trend and Stochastic Seasonality - Brownian Motions and Simulation - Stationarity, Nonstationarity, and Unit Root Tests - Cointegrations and Granger's Representation Theorem.

Learning Resources:

Text Books:

1. **Changquan Huang, Alla Petukhina,** Applied Time Series Analysis and Forecasting with Python, Springer, 2022, First Edition.
2. **Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci,** Introduction to Time Series Analysis and Forecasting, Wiley, 2015, Second Edition.

Reference Books:

1. **Mills, Terence C**, Applied time series analysis: a practical guide to modeling and forecasting, Elsevier, Academic Press, 2019, First Edition.
2. **Wayne A. Woodward, Bivin Philip Sadler, Stephen Robertson,** Time Series for Data Science: Analysis and Forecasting, CRC Press, 2022, First Edition.

CD1332 **3-0-0 (3)**

Compiler Design

Pre-Requisites: None

Course Outcomes:

CO-1	Understand phases in the design of compiler.
CO-2	Design top-down and bottom-up parsers.
CO-3	Identify synthesized and inherited attributes.
CO-4	Develop syntax directed translation schemes.
CO-5	Develop algorithms to generate code for a target machine.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-2	1	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-
CO-3	2	2	2	-	-	2	-	-	-	-	-	-	1	-	-	-
CO-4	2	1	-	-	2	-	-	-	-	-	-	-	2	-	-	-
CO-5	1	-	-	1	-	-	-	-	-	-	-	-	3	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: The structure of a compiler; The evolution of programming languages; The science of building a compiler; Application of compiler technology; Programming language basics.
A Simple Syntax-Directed Translator: Introduction; Syntax definition; Syntax-directed translation; Parsing; A translator for simple expressions; Lexical analysis; Symbol tables; Intermediate code generation.
Lexical Analysis: The role of the lexical analyzer; Input buffering; Specification of tokens; Recognition of tokens; The lexical-analyzer generator Lex; Finite automata; From regular expressions to automata; Design of a lexical-analyzer generator; Optimization of DFA-based pattern matchers.
Syntax Analysis: Introduction; Context-free grammars; Writing a grammar; Top-down parsing; bottom-up parsing; Introduction to LR parsing: simple LR; More powerful LR parsers; Using ambiguous grammars; Parser generators.
Syntax-Directed Translation: Syntax-directed definitions; Evaluation orders of SDD's; Applications of syntax-directed translation; Syntax-directed translation schemes; Implementing l-attributed SDD's.
Intermediate-Code Generation: Variants of syntax trees; Three-address code; Types and declarations; Translation of expressions; Type checking; Control flow; Backpatching; Switch-statements; Intermediate code for procedures.
Run-time environments: Storage organization; Stack allocation of space; Access to nonlocal data on the stack; Heap management; Introduction to garbage collection; Introduction to trace-based collection; Short-pause garbage collection; Advanced topics in garbage collection.
Code Generation: Issues in the design of a code generator; The target language; Addresses in the target code; Basic blocks and flow graphs; Optimization of basic blocks; A simple code generator; Peephole optimization; Register allocation and assignment; Instruction selection by tree rewriting; Optimal code generation for expressions; Dynamic programming code-generation.

Learning Resources:

Text Books:

1. **Alfred V. Aho, Monical S.Lam, Ravi Sethi, and Jeffrey D. Ullman** "Compilers - Principles, Techniques and Tools", 2nd Edition, Pearson, 2007.

Reference Books:

1. **Ken Kennedy and Randy Allen**, Optimizing Compilers for Modern Architectures: A Dependence-Based

Approach, Morgan Kaufmann Publishers, 2001.

Other Suggested Readings:

1. NPTEL Course on Compiler Design by Prof. Y. N. Srikanth, IISc. Bangalore, Prof. Sanjeev K. Aggarwal, IIT Kanpur, Prof. Santanu Chattopadhyay, IIT Kharagpur.

CD1334 **3-0-0 (3)**

Object Oriented Programming with JAVA

Pre-Requisites: None

Course Outcomes:

CO-1	Introduce the fundamental concepts
CO-2	Provide a foundation to use basic concepts
CO-3	Learn to write Programming
CO-4	Learn overloading, inheritance, file handling

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	2	2	-	2	-	-	-	-	-	-	2	1	-	2	-
CO-2	1	-	2	-	2	1	-	-	2	-	1	1	-	-	-	1
CO-3	1	-	2	-	2	1	-	-	2	-	1	-	-	2	1	
CO-4	1	2	2	1	2	1	1	1	2	-	1	2	2	-	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Basics: Object oriented languages – Applications of OOP. Comments, data types, variables, constants, scope and life time of variables, operators, operator hierarchy, expressions, type conversion and casting, enumerated types, control flow-block scope, conditional statements, loops, break and continue statements, simple program, arrays, input and output, formatting output.

Overloading: Overloading unary operators-overloading binary operators-overloading binary operators using Friends - Rules for overloading operators – function overloading, Type conversions.

Inheritance: Inheritance concept, benefits of inheritance, Member access rules, Inheritance hierarchies, super uses, casting, polymorphism- dynamic binding, method overriding, abstract classes and methods, the Object class and its methods.

Interfaces: Interfaces vs. Abstract classes, defining an interface, implementing interfaces, accessing implementations through interface references, extending interface.

Files: Files – streams- byte streams, character streams, text Input/output, binary input/output, random access file operations, File management using File class.

Learning Resources:

Text Books:

1. **Timothy Budd,** "Object Oriented Programming with JAVA", Updated Edition, Pearson Education, 2009.
2. **Cay S. Horstmann and G. Cornell,** Core Java, Volume 1-Fundamentals, Pearson, 2013, Ninth Edition.
3. **H. Schildt,** Java: the complete reference, McGraw Hill, 2011, Seventh Edition.
4. **P.J. Deitel and H.M.Deitel,** Java for Programmers, Pearson, 2009, Second Edition.

Reference Books:

1. **D.S. Malik,** Java Programming, Cengage Learning, 2009 and Edition.
2. **R.A. Johnson,** An introduction to Java programming and object-oriented application development, Cengage Learning, 2007.

CD1336 **3-0-0 (3)**

Computer Vision and Image Processing

Pre-Requisites:

Course Outcomes:

CO-1	Understand Image representation and modeling.
CO-2	Apply Image transformation methods.
CO-3	Implement image processing algorithms.
CO-4	Design of face detection and recognition algorithms.
CO-5	Analyze the features and propose new features of images.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	2	2	2	2	1	2	2	2	1	3	2	3	2
CO-2	3	2	3	2	2	2	3	1	3	3	3	1	3	3	2	2
CO-3	3	2	3	2	3	2	3	1	3	3	3	1	2	3	2	2
CO-4	2	2	3	2	2	2	3	1	3	3	3	1	3	3	2	2
CO-5	2	3	2	3	1	2	2	1	2	2	2	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

The image model and acquisition, image shape, sampling, intensity images, color images, range images, image capture, scanners. Statistical and spatial operations, Gray level transformations, histogram equalization, multi-image operations. Spatially dependent transformations, templates and convolution, window operations, directional smoothing, other smoothing techniques. Segmentation and Edge detection, region operations, Basic edge detection, second order detection, crack edge detection, edge following, gradient operators, compass & Laplace operators. Morphological and other area operations, basic morphological operations, opening and closing operations, area operations, morphological transformations. Image compression: Types and requirements, statistical compression, spatial compression, contour coding, quantizing compression. Representation and Description, Object Recognition, 3-D vision and Geometry, Digital Watermarking. Texture Analysis.

Learning Resources:

Text Books:

1. **D. A. Forsyth, J. Ponce,** Computer Vision: A Modern Approach, PHI Learning, 2009.
2. **Milan Soanka, Vaclav Hlavac and Roger Boyle,** Digital Image Processing and Computer Vision,Cengage Learning, 2014.

Reference Books:

1. **R.C. Gonzalez and R.E. Woods,** Digital Image Processing, Pearson Education, 2007.

CD1338 **3-0-0 (3)**

Advanced Databases

Pre-Requisites: None

Course Outcomes:

CO-1	Design distributed database for application development.
CO-2	Apply query optimization principles for optimizing query performance in centralized and distributed database systems.
CO-3	Design distributed database schema using principles of fragmentation and allocation.
CO-4	Apply distributed transaction principles for handling transactions in distributed database applications.
CO-5	Apply distributed database administration principles for managing distributed database.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	1	1	-	-	1	1	1	1	1	3	2	-	1
CO-2	2	2	2	1	1	-	-	1	-	-	1	1	1	1	-	2
CO-3	1	2	3	1	1	-	-	1	1	1	1	1	3	2	-	1
CO-4	1	1	1	1	2	-	-	1	1	1	1	1	1	2	1	1
CO-5	-	-	1	1	1	2	-	-	1	1	1	1	1	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Database-System Architectures: Centralized Database Systems, Server System Architectures, Parallel Systems, Distributed Systems, Transaction Processing in Parallel and Distributed Systems, Cloud-Based Services Parallel and Distributed Storage: Data Partitioning, Dealing with Skew in Partitioning, Replication, Parallel Indexing, Distributed File Systems, Parallel Key-Value Stores

Parallel and Distributed Query Processing: Parallel Sort, Parallel Join, Other Operations, Parallel Evaluation of Query Plans, Query Processing on Shared-Memory Architectures, Query Optimization for Parallel Execution, Parallel Processing of Streaming Data, Distributed Query Processing

Parallel and Distributed Transaction Processing: Distributed Transactions, Commit Protocols, Concurrency Control in Distributed Databases, Replication, Extended Concurrency Control Protocols, Replication with Weak Degrees of Consistency, Coordinator Selection, Consensus in Distributed Systems

Advanced Indexing Techniques: Bloom Filter, Log-Structured Merge Tree and Variants, Bitmap Indices, Indexing of Spatial Data, Hash Indices.

Block chain Databases: Block chain Properties, Achieving Block chain Properties via Cryptographic Hash Functions, Consensus, Data Management in a Block chain, Smart Contracts, Performance Enhancement, Emerging Applications

No SQL databases: Types, CAP theorem, Key-values storage, Column value storage, Scalability and Performance, Use cases, AI and Machine Learning Integrations

Learning Resources:

Text Books:

1. **M T Ozsu, Patrick Valduriez**, "Principles of Distributed Database Systems", Prentice Hall, 1999.
2. **S. Ceri and G. Pelaggati**, "Distributed Database System Principles and Systems", MGH, 1985.

CD1340 **3-0-0 (3)**

Bio Informatics

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the theoretical basis behind bioinformatics.
CO-2	Compute homologues, analyze sequence alignment and similarity.
CO-3	Understand the Management Information System, Decision support system, Expert system.
CO-4	Analyze various gene sequences, gene prediction, and categories of gene prediction.
CO-5	Determine and model biological information and apply to the solution of biological problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	-	2	-	3	-	-	1	-	-	-	-	1	1	2	-
CO-2	-	2	3	-	-	1	2	3	-	2	-	-	1	1	3	1
CO-3	3	-	2	-	3	-	-	-	3	-	-	3	-	2	3	1
CO-4	2	3	2	3	2	-	-	3	-	1	2	-	1	1	3	1
CO-5	-	2	3	-	1	-	3	-	2	2	3	3	1	2	2	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Bioinformatics: What is a Database?, Types of Databases, Biological Databases, Biological Databases, Information Retrieval from Biological Databases.
Pair wise Sequence Alignment: Evolutionary Basics, Sequence homology versus similarity, Sequence similarity versus Identity, Scoring Matrices, Statistical Significance of Sequence alignment.
Database similarity searching: Unique requirement of Database searching, Heuristic Database searching.
Basic alignment search tool: Comparison of FASTA and BLAST, Multiple Sequence Alignment, Scoring Function, Gene Prediction, Categories of gene prediction, Gene prediction in prokaryotes and Eukaryotes.
Introduction to Agri-informatics: Importance of Agriculture to Development and the Contribution of ICTs, Critical Information Flows and the Agricultural Knowledge System, The Feasibility of ICT in Rural Areas, Financial Aspects: Up-front Costs and Long-term Benefits of ICT Approaches, Technical Aspects of ICT Feasibility in Rural Areas, Promising Emerging Technologies, Some major ICT trends, Some high impact innovations, Hardware and Connectivity, Ubiquitous Telecommunication Infrastructure, Utility or Cloud Computing, Software and Content Management, Interaction with Biology, Biotechnology, Nanotechnology, Materials Science and ICTs, Information and Communication Technology in Agricultural Development, Convergence of ICT with agricultural development, Areas of IT convergence, Drivers of ICT in Agriculture, Low-Cost and Pervasive Connectivity, Adaptable and More Affordable Tools, New Business Models and Public-Private Partnerships, Democratization of Information, the Open Access Movement and Social Media, Use Appropriate Technologies, Making ICT Infrastructure, Appliances and Services, Accessible and Affordable in Rural Areas, Key Challenges and Enablers, Partnerships, Regulation and Policy Challenges, Infrastructure, Local Loop or Last Mile Connectivity, Appliances, Services, Anytime, Anywhere: Mobile Devices and Services, Applications in Agriculture, Information Systems in Agriculture: Introduction, Information systems and communication networks, Management Information Systems, Internal Information Systems, External Information Systems, Farm Management Information System (FMIS), Farm Management Information System. Decision Support Systems: Introduction, Historical Overview of Decision Support Systems (DSS), Future trends, Decision Support Systems in Agriculture. Expert Systems and Applications: Introduction, what is an Expert System, Expert Systems and Human Reasoning, Structural Nature of Expert Systems, Characteristics of Expert System Applications, Knowledge Acquisition, Knowledge Representation, Explanation, Expert System Strengths and Limitations, Extensions to Expert Systems.

Learning Resources:

Text Books:

1. **Jin Xiong**, "Essential Bioinformatics", 1st Edition, Cambridge University Press, 2011.
2. **Arthur M Lesk**, "Introduction to Bioinformatics", 2nd Edition, Oxford University Press, 2007.

Reference Books:

1. **Zhumur Ghosh,** “Bioinformatics” 2nd Edition, Oxford University Press, 2009.
2. **Herdon, Miklos**, “Agriinformatics” 2nd Edition Cambridge University Press 2013.

CD1421 **3-0-0 (3)**

Cryptography

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the principles of modern cryptography and perfect secrecy.
CO-2	Learn the design principles of stream ciphers, DES and AES.
CO-3	Analyse RSA and ElGamal public key cryptosystems.
CO-4	Learn elliptic curve cryptosystems and digital signature schemes.
CO-5	Know the security concepts such as CPA, CCA and existential unforgeability.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	–	1	1	–	–	–	–	–	1	3	–	–	3
CO-2	2	1	3	–	–	–	–	–	–	–	–	3	3	–	–	3
CO-3	–	1	3	–	–	–	–	–	–	–	–	2	3	–	–	3
CO-4	2	1	3	–	–	–	–	–	–	–	–	3	3	–	–	3
CO-5	–	2	3	–	–	–	–	–	–	–	–	–	2	–	–	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Review on basic group theory and basic number theory, basic facts of elliptic curves, Historical ciphers and their cryptanalysis, Principles of modern cryptography, perfect secrecy and one-time pad.

Private-key Cryptography: Hash functions, Stream ciphers, Block ciphers - SPN, Feistel design, DES, AES, Modes of operation. Introduction to differential and linear cryptanalysis.

Public-key Cryptography: RSA Cryptosystem, Diffie-Hellman key-exchange protocol, Discrete-Logarithm Problem (DLP), ElGamal Cryptosystem, elliptic-curve cryptosystem, digital signatures, homomorphic encryption, signcryption. Chosen plaintext attack (CPA) and chosen ciphertext attack (CCA) security, existential unforgeability.

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Learning Resources:

Text Books:

1. **Douglas R. Stinson,** Cryptography: Theory and Practice, Chapman & Hall/CRC, 2006, Third Edition.
2. **William Stallings**, Cryptography and Network Security: Principles and Practice, Pearson, 2017, Seventh Edition.
3. **Dan Boneh** and **Victor Shoup,** A Graduate Course in Applied Cryptography, version 0.6, 2023, available at http://toc.cryptobook.us/

Reference Books:

1. **Christof Paar and Jan Pelzl**, Understanding Cryptography, Springer, 2010.
2. **Jonathan Katz and Yehuda Lindell**, Introduction to Modern Cryptography, CRC Press, Taylor & Francis Group, 2015, Second Edition.

CD1423 **3-0-0 (3)**

Stochastic Models and Applications

Pre-Requisites: **MA1163, MA1264**

Course Outcomes:

CO-1	Understand the fundamental concepts of probability theory and stochastic processes, including discrete and continuous-time models.
CO-2	Formulate real-world systems using appropriate stochastic models such as Poisson processes, Markov chains, and renewal processes.
CO-3	Analyze the behavior of Markov chains.
CO-4	Apply stochastic modeling techniques to systems in engineering.
CO-5	Use simulation methods and tools for solving and validating stochastic models.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	1	2	_	_	_	_	_	_	_	1	2	2	2
CO-2	2	2	3	1	2	_	_	_	_	_	_	_	3	2	2	2
CO-3	3	2	2	-	-	_	_	_	_	_	_	_	2	1	1	2
CO-4	2	2	3	1	2	_	_	_	_	_	_	_	3	2	2	2
CO-5	2	2	2	1	2	_	_	_	_	_	_	_	1	2	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Probability Theory Refresher: Axiomatic construction of probability spaces, random variables and vectors, probability distributions, functions of random variables; mathematical expectations, transforms and generating functions, modes of convergence of sequences of random variables, laws of large numbers, central limit theorem.

Stochastic Processes: Definition and examples of SPs, classification of random processes according to state space and parameter space, types of SPs, elementary problems, Weakly stationary and strongly stationary processes, moving average and auto regressive processes.

Markov Chains: Definition and examples of MCs, transition probability matrix, Chapman-Kolmogorov equations; calculation of n-step transition probabilities, limiting probabilities, classification of states, ergodicity, stationary distribution, transient MC;random walk and gambler's ruin problem, applications. Kolmogorov- Feller differential equations, infinitesimal generator,Poisson process, birth-death process, stochastic Petri net, applications to queueing theory and communication networks.

Martingales: Conditional expectations, definition and examples of martingales.

Brownian Motion: Wiener process as a limit of random walk; process derived from Brownian motion, stochastic differential equation, stochastic integral equation, Ito formula, Some important SDEs and their solutions, applications to finance.

Renewal Processes: Renewal function and its properties, renewal theorems, cost/rewards associated with renewals, Markov renewal and regenerative processes, non Markovian queues, applications of Markov regenerative processes

Branching Processes: Definition and examples branching processes, probability generating function, mean and variance, Galton-Watson branching process, probability of extinction.

Learning Resources:

Text Books:

1. P.Z. Peebles.Jr., Probability, Random Variables AND Random Signal Principles, Tata McGraw Hill Education, 2017, 4 th Edition.
2. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 2017, 4 th Edition.
3. Scott Miller, Donald Childersm, Probability and Random Processes, Elsevier, 2012, 2 nd Edition.

Reference Books:

1. Athanasios Papoulis and S., Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, TMH, 2002, 4th Edition.
2. Pradip Kumar Gosh, Theory of Probability and Stochastic Processes, University Press

CD1425 **3-0-0 (3)**

Data Warehousing and Data Mining

Pre-Requisites:

Course Outcomes:

CO-1	Understand stages in building a Data Warehouse.
CO-2	Apply preprocessing techniques for data cleansing.
CO-3	Analyze multi-dimensional modeling techniques.
CO-4	Analyze and evaluate performance of algorithms for Association Rules.
CO-5	Analyze Classification and Clustering algorithms.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	-	1	1	1	1	–	–	–	–	–	1	–	1	3	1
CO-2	2	2	3	3	3	1	–	2	–	–	–	1	2	1	2	-
CO-3	1	1	3	3	3	1	1	1	–	–	1	1	3	1	2	1
CO-4	1	1	3	3	3	1	1	2	–	–	1	1	3	2	3	1
CO-5	1	1	3	3	3	1	1	2	–	–	1	1	3	2	3	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Data Warehousing: KDD Process, Introduction to Data Warehouse, Data Preprocessing- Data Cleaning methods, Descriptive Data Summarization, Data Reduction, Data Discretization and Concept hierarchy generation, Overview of ETL and OLAP OLTP integration – comparison of OLAP with OLTP systems, ROLAP, MOLAP and DOLAP, Data Cube Computation methods, Advanced SQL support for OLAP, Multi- dimensional Modeling, Attribute-oriented Induction, Data Warehouse architecture and implementation - Parallel execution, Materialized views.

Data Mining: Introduction, Basic concepts of Association Rule Mining, Frequent Item set mining, Mining various kinds of association rules, Classification by decision tree induction, Bayesian Classification, Rule- based Classification, Classification Back-propagation, Associative Classification, Lazy Learners.
Clustering methods, Data Objects and Attribute Types, Basic Statistical Descriptions of Data, Measuring Data Similarity and Dissimilarity Partition based Clustering, Hierarchical based clustering, Density based clustering.

Learning Resources:

Text Books:

1. **Jiawei Han and M Kamber**, Data Mining Concepts and techniques, Morgan Kaufmann Publishers In, 2022, Fourth Edition.

Reference Books:

1. **Pang-Ning Tan, Michael Steinbach, Anuj Karpatne and Vipin Kumar**, Introduction to Data Mining, Pearson, 2018, Second Edition.
2. **Alex Berson, Stephen Smith**, Data Warehousing, Data Mining & OLAP, McGrawHill, 2017, First Edition.

CD1427 **3-0-0 (3)**

Cloud Computing

Pre-Requisites:

Course Outcomes:

CO-1	Understand cloud computing concepts and history.
CO-2	Mastering principles of parallel and distributed computing.
CO-3	Proficiency in virtualization techniques.
CO-4	Analyzing cloud computing architectures.
CO-5	Familiarity with industry cloud platforms.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	-	2	-	2	-	-	-	-	2	2	-	-	2
CO-2	3	3	2	2	2	1	2	-	2	2	-	2	3	3	2	2
CO-3	3	3	2	3	2	2	2	-	2	2	2	2	3	3	2	2
CO-4	3	3	2	2	2	1	2	-	2	2	-	2	3	2	-	3
CO-5	-	-	3	-	3	2	2	-	-	2	2	2	2	-	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Cloud computing at a glance; Historical developments; Building cloud computing environments
Principles of Parallel and Distributed Computing: Eras of computing; Parallel vs. distributed computing; Elements of parallel computing; Elements of distributed computing; Technologies for distributed computing
Virtualization: Introduction; Characteristics of virtualized environments; Taxonomy of virtualization techniques; Virtualization and cloud computing; Pros and cons of virtualization; Technology examples
Cloud Computing Architecture: Introduction; The cloud reference model; Types of clouds; Economics of cloud; Open challenges
Cloud Platforms in Industry: Amazon web services; Google AppEngine; Microsoft Azure
Cloud Applications: Scientific applications; business and consumer applications
Advanced Topics in Cloud Computing: Energy efficiency in clouds; Market-based management of clouds; Federated clouds/Intercloud; Third-party cloud services; Resource allocation; Task scheduling; Service management; Data management; Resource management; Security and privacy; Edge computing; Fog computing; Osmotic computing
Toolkits: CloudAnalyst; CloudSim; iFogSim; Haizea – An open source VM-based lease manager

Learning Resources:

Text Books:

1. **Rajkumar Buyya, James Broberg, Andrzej Goscinski**, Cloud Computing Principles and Paradigms, Wiley, 2011,MGH, 2010.

Reference Books:

1. **Barrie Sosinsky**, Cloud Computing Bible, Wiley Publishing, 2011.
2. **Tim Mather, Subra Kumaraswamy and Shahed Latif**, Cloud Security and Privacy, O'Reilly, 2009**.**

Other Suggested Readings

2. NPTEL Course on Cloud Computing by Prof. Soumya Kanti Ghosh, IIT Kharagpur, Prof. Rajiv Mishra, IIT Patna, Prof. Bidisha Chaudhuri, Prof. Amit Prakash, IIIT Bangalore.

CD1429 **3-0-0 (3)**

Internet of Things

Pre-Requisites:

Course Outcomes:

CO-1	Analyze the protocol Stack for Internet of Things to address the heterogeneity in devices and networks.
CO-2	Develop smart IoT Applications using smart sensor devices and cloud systems.
CO-3	Development of smart mobile apps for societal applications.
CO-4	Design secure protocols for IoT systems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	3	-	-	-	-	-	-	2	2	2	2	2	2
CO-2	3	3	3	3	3	2	2	-	2	2	2	2	2	2	3	3
CO-3	3	3	3	3	3	2	2	-	2	2	2	2	2	3	2	3
CO-4	2	3	2	2	2	-	-	-	-	-	2	2	2	3	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to IoT- Concepts, Services, Characteristics, Challenges and Applications of IoT- Smart City, Health-Care, Architecture of IoT - ITU, IWF, Integration of OT and IT technologies, IoT Data Flow,

IoT Protocols- Protocols Architecture of IoT**,** IoT Protocol Standards, Categorization of IoT protocols, Non-IP Network Technologies of IoT, IP Network Technologies, Service Discovery Protocols for IoT, Application Protocols, Protocol Stack of Wireless IoT.

IoT System Design- Components of IoT System, Communications Models of IoT, IoT Platforms- Open- Source & Proprietary Platforms

Sensor and Identification Technologies of IoT- Edge Devices of IoT- Sensors and Actuators, WSN, RFID, Integration of RFID and WSN Network Technologies

Connectivity of IoT-Wireless IoT, Non-IP Wireless Connectivity- 802.11ah, 802.15 technologies, Wireless Embedded Internet, and IoT Routing, IP Connectivity- Mobile IP, BLE over IPv6, ZigBee over IPv6, RFID over IPv6.

Service Technologies of IoT- Edge and Fog Computing in IoT, Cloud Computing in IoT.

IoT Security- Security Requirements, Vulnerabilities and Threat Analysis, Layered Attacker model and Blockchain in IoT Security

Learning Resources:

Text Books:

1. **Olivier Hersent**, “The Internet of Things Key Applications and Protocols”, Wiley, 2012**.**
2. **Sudip Misra**, “Introduction to IoT”, Cambridge University Press; First edition , 2021.

Reference Books:

1. **Bahga. Arshdeep, Madisetti. Vijay**, Internet of Things (A Handson-on Approach), publisher: Vijay Madisetti, 2014.
2. **Raj Kamal,** "Internet of Things: Architecture and Design Principles", McGraw Hill Education private limited, 2017.

CD1431 **3-0-0 (3)**

Quantum Computing and Algorithms

Pre-Requisites:

Course Outcomes:

CO-1	Understand quantum computing principles.
CO-2	Design and analyze quantum circuits and algorithms.
CO-3	Implement quantum circuits and algorithms using Qiskit.
CO-4	Understand fundamentals of quantum communication.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	1	–	–	–	–	–	–	–	–	1	2	1	–	–
CO-2	2	3	3	2	–	–	–	–	–	–	–	3	3	–	–	–
CO-3	2	2	2	2	–	–	–	–	–	–	–	–	2	2	–	1
CO-4	2	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Preliminaries: Review of linear algebra and complex numbers.

Quantum Computation: Introduction to qubits, Multiple qubits, Dirac notation, Bloch sphere, Reversable Gates, Basic single- qubit gates, Two-qubit gates, Measurements, Quantum circuits, Bell state circuit, No-cloning theorem, Teleportation, Amplitude Amplification, Superdense coding, Physical realizations of qubits and Qiskit.

Quantum Algorithms: Introduction to query complexity, Deutsch algorithm, Deutsch-Josza algorithm, Bernstein-Vajirani algorithm, Simon`s algorithm, Quantum Fourier Transform, Quantum Phase Estimation, Grover`s Search Algorithm, Ordering finding using phase estimation, Shor`s algorithm, Quantum key distribution, BB84 protocol and HHL algorithm.

Learning Resources:

Text Books:

1. **Michael A. Nielsen and Issac L. Chuang**, Quantum Computation and Quantum Information,. Cambridge, 2010, 10th Anniversary Edition.
2. **Noson S. Yanofsky and Mirco A. Mannucci**, Quantum Computing for Computer Scientists, Cambridge University Press, 2008, 1st Edition.

Reference Books:

1. **Eleanor G. Rieffel and Wolfgang H. Polak**, Quantum Computing: A Gentle Introduction, MIT Press, 2011.
2. **Hassi Norlén,** Quantum Computing in Practice with Qiskit(R) and IBM Quantum Experience(R): Practical recipes for quantum computer coding at the gate and algorithm level with Python, Packt Publishing, 2020.

Other Suggested Readings:

1. IBM Quantum Learning Courses: https://learning.quantum.ibm.com/ .
2. YouTube Link: Introduction to Quantum Computing Complete Course - Quantum Soar.

CD1433 **3-0-0 (3)**

Social Media Analytics

Pre-Requisites:

Course Outcomes:

CO-1	Understand the importance of social media and networks.
CO-2	Enhance analytical skills for analyzing social media and networking data.
CO-3	Develop skills to leverage extended enterprise data.
CO-4	Create real-life case studies using social media data.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	-	1	-	1	-	-	1	-	-	1	-	1	-	-	1
CO-2	1	-	-	2	2	2	2	-	-	1	2	-	-	-	2	-
CO-3	1	2	2	-	1	-	2	-	-	2	-	2	-	2	-	2
CO-4	-	1	1	2	-	2	-	1	2	-	-	1	-	2	-	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to social network analysis: Vertex or node, edge, neighbors, degree, shortest path, cycle, tree, complete graph, bipartite graphs, directed graphs, weighted graphs, adjacency matrix;

Social networks examples (facebook, movie collaboration, and paper collaboration), information networks (web), biological networks (neural networks, ecological networks), random graphs with general degree distributions, models of network formation, Properties of Large-Scale Networks: Six-degree separation, scale-free distributions, small-world effect, and strong community structure;

Networks and Centrality Measures: Degree, closeness, betweenness, edge betweenness, eccentricity, clustering coefficient, eigenvector; Spread of influence through a network, influence maximization in networks, spread of disease on networks, Information networks;

Community Detection and graph based clustering: communities in social media, node-centric community detection, group-centric community detection, network-centric community detection, hierarchy-centric community detection, Topology discovery. Community Evaluation;

Link Prediction: Challenges in link prediction, link prediction methods and algorithms, clustering approaches for link prediction;

Sentiment Analysis: Sentiments and Opinions, lexicon based methods, machine learning based methods, feature-based sentiment analysis, slang sentiment analysis;

Social Listening and Social Recommendation Systems: Social Recommendation Using collaborative filtering, community detection and probabilistic matrix factorization.

Learning Resources:

Text Books:

1. **Reza Zafarani, Mohammad Ali Abbasi, Huan Liu**, Social Media Mining – An Introduction, Cambridge University Press, 2014.
2. **Charu C Aggarwal** (Ed.), Socail Network Data Analytics, Springer, 2011.
3. **Hansen, Derek, Ben Sheiderman, Marc Smith**., Analyzing Social Media Networks with NodeXL: Insights from a Connected World, Morgan Kaufmann, 2011.

CD1435 **3-0-0 (3)**

Pattern Recognition

Pre-Requisites:

Course Outcomes:

CO-1	Understand and Design Unsupervised Learning Methods.
CO-2	Design Regression model to solve the classification and prediction problems.
CO-3	Design Neural network to solve classification and function approximation problems.
CO-4	Build optimal classifiers using genetic algorithms and Support vector machines.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	2	1	1	-	1	–	1	1	1	-	2	1	2	-
CO-2	2	2	1	1	1	-	-	–	–	1	1	-	2	1	2	-
CO-3	2	2	2	2	1	1	1	–	–	1	1	1	2	1	3	-
CO-4	2	2	2	2	1	1	1	–	–	1	1	1	2	1	3	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Well defined learning problems, Designing a Learning System, Dimensionality Reduction, PCA, LDA; Introduction to Statistical Decision Theory - Regression, Linear Regression, Multivariate Regression and Logistic Regression; Unsupervised Learning Methods: Clustering, Partitional, Hierarchical and Density based clustering Methods; DECISION TREE LEARNING - Decision tree learning algorithm-Inductive bias- Issues in Decision tree learning; Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting; Bayesian Learning – Bayes theorem, Concept learning, Bayes Optimal Classifier, Naïve Bayes classifier, Bayesian belief networks, EM algorithm; ARTIFICIAL NEURAL NETWORKS – Perceptron, Gradient descent and the Delta rule, Adaline, Multilayer networks, Derivation of back-propagation rule-Back-propagation Algorithm, Convergence, Generalization; Support vector Machines; Instance-Based Learning – k-Nearest Neighbor Learning, Locally Weighted Regression.

Learning Resources:

Text Books:

1. **Tom.M.Mitchell**, "Machine Learning", McGraw Hill International Edition, 1997.
2. **C Bishop**, "Pattern Recognition and Machine Learning", Springer, 2006.

CD1437 **3-0-0 (3)**

Foundations of Blockchain Technology

Pre-Requisites: **None**

Course Outcomes:

CO-1	To understand the essential concepts and structural components of blockchain and the rationale behind its implementation.
CO-2	To understand the core technology, many types of blockchains and protocols that operate the blockchain.
CO-3	To articulate and develop and test blockchain-compatible diverse applications with smart contracts.
CO-4	To understand and analyze the advantages and disadvantages of employing blockchain technology in various industries and technologies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	2	2	-	-	-	-	-	-	2	2	2	2	2	2
CO-2	2	2	2	2	2	2	2	-	2	2	2	2	2	2	3	3
CO-3	3	3	3	3	3	3	3	-	3	3	3	3	3	3	3	3
CO-4	3	3	2	2	2	-	-	-	3	3	3	3	3	3	3	3

Syllabus:

Introduction to Blockchain- Key Concepts of Blockchain, Features of Blockchain, Importance of Blockchain, Blockchain 1.0, 2.0, and 3.0, Issues to Centralized System, Centralized to Decentralized and Distributed System, Building Blocks of Blockchain- Distributed Ledgers & P2P Networks, Block Header, Transaction Organization.

Cryptographic Primitives, Basic Crypto Primitives- Hash Functions- Properties of Hash Function, Nonce, Merkle Trees, Hash Pointers, Public Key Cryptography- Public/private keys, Signature schemes, Signature correctness,

Decentralization- Distributed shared ledger, Distributed Consensus-Distributed Consensus Protocol. Classical theory of consensus, Byzantine Generals Problem possibility and impossibility results, Asynchronous consensus and Byzantine Fault Tolerance

Types of Blockchain- Permission-less Blockchain- Bitcoin-Introduction to Bitcoin, Bitcoin Transaction, Bitcoin Protocol, Bitcoin Wallets, Bitcoin Block, Bitcoin Scripts, Bitcoin Network, Bitcoin Mining-Nakamoto Consensus- Proof-of-work, Mining target T, Proof-of-work equation, Mining Algorithm, Mining and reward, Block freshness, Partial and full nodes, Attacks on Bitcoin- Double-spend attacks, Selfish mining, Ethereum Blockchain, Introduction to Ethereum, Ethereum Networks, Ethereum Wallets, Ethereum Clients, Ethereum accounts, Transactions and State, Smart contracts, Privacy-preserving smart contracts, Proof-of-stake, Variants of Ethereum blockchain

Permissioned Blockchain- Hyperledger Fabric-, State Machine Replication, Distributed State Machines, MSP, Consensus- Raft Consensus Algorithm, Safety and liveness, Privacy based blockchain, ZCash, Zero-knowledge-proof, R3 Corda, Corda Network

Blockchain Security- Attacks on Blockchain and their Countermeasures, Application & Use cases of Blockchain

Learning Resources:

Text Books:

1. **A. Narayanan, J. Bonneau, E. Felten, A. Miller and S. Goldfeder,** Bitcoin and Cryptocurrency Technologies, Princeton University Press. Henceforth termed as PUP (Princeton university press).
2. **Imran Bashir,** Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing, 2020, ISBN: 9781839213199.

Reference Books:

1. **William Magnuson,** "Blockchain Democracy- Technology, Law and the Rule of the Crowd", Cambridge University Press, 2020.
2. **Pethuru Raj, Kavita Saini, Chellammal Surianarayanan**, "Blockchain Technology and Applications", CRC Press, 2021.

Other Suggested Readings:

1. Introduction to Cryptocurrencies, a basic online course by **Haseeb Qureshi**.

CD1422 **3-0-0 (3)**

Fuzzy Mathematics

Pre-Requisites:

Course Outcomes:

CO-1	Understand the relation between imprecise data and fuzzy sets.
CO-2	Deal with arithmetic operations of fuzzy numbers.
CO-3	Understand fuzzy rule-based implications and approximate reasoning.
CO-4	Distinguish between the possibility and probability.
CO-5	Apply fuzzy tools to solve optimization problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	1	2	–	–	–	3	–	–	–	–	–	1	2	1	2
CO-2	–	2	3	2	–	–	–	–	–	–	–	–	2	2	1	–
CO-3	1	1	2	–	–	–	3	–	–	–	–	–	1	2	1	2
CO-4	–	2	3	2	–	–	–	–	–	–	–	–	2	2	1	–
CO-5	3	–	–	–	3	3	–	3	–	–	–	–	1	1	1	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

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, Convex fuzzy sets, Alpha-level cuts, Geometric interpretation of fuzzy sets. Fuzzy extension principle and its application.

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.

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.

Fuzzy optimization: Decision making in Fuzzy environment, Fuzzy Multi criteria decision making, Fuzzy Linear programming.

Learning Resources:

Text Books:

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

Reference Books:

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

CD1424 **3-0-0 (3)**

Multiobjective Programming

Pre-Requisites:

Course Outcomes:

CO-1	Explain the genetic principles underlying evolutionary computation.
CO-2	Apply genetic algorithms and programming to solve optimization challenges.
CO-3	Gain insight into recent evolutionary algorithms and their applications.
CO-4	Develop appropriate evolutionary algorithms to solve real-world problems.
CO-5	Tackle complex optimization challenges using evolutionary computation techniques.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	2	3	2	2	–	–	–	–	–	–	–	2	2	1	2
CO-2	3	–	–	–	3	3	–	3	–	–	–	–	1	2	2	1
CO-3	2	2	3	2	2	–	–	–	–	–	–	–	2	2	1	2
CO-4	1	3	1	–	–	–	–	–	–	–	–	–	–	3	1	2
CO-5	2	2	3	2	2	–	–	–	–	–	–	–	2	2	1	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Overview of optimization problems - History and philosophy of evolutionary computation - Basic principles of natural selection and genetics.

Genetic Programming and Algorithms: The History of Genetic Algorithms - A Simple Binary Genetic Algorithm - A Genetic Algorithm for Robot Design - Selection and Crossover – Mutation - GA Summary - GA Tuning Parameters and Examples - A Simple Continuous Genetic Algorithm; Mathematical Models of Genetic Algorithms – Selection – Mutation – Crossover - Dynamic System Models of Genetic Algorithms; Evolutionary Programming; Evolution Strategies; Genetic Programming; Evolutionary Algorithm Variations.

Recent Evolutionary Algorithms: Simulated Annealing; Ant Colony Optimization; Particle Swarm Optimization; Differential Evolution; Estimation of Distribution Algorithms; Biogeography-Based Optimization; Cultural Algorithms; Opposition-Based Learning; Other Evolutionary Algorithms - Tabu Search - Artificial Fish Swarm Algorithm - Group Search Optimizer - Shuffled Frog Leaping Algorithm - The Firefly Algorithm - Bacterial Foraging Optimization - Artificial Bee Colony Algorithm - Gravitational Search Algorithm - Harmony Search - Teaching-Learning-Based Optimization.

Learning Resources:

Text Books:

1. **D. Simon,** Evolutionary optimization algorithms, Wiley, 2013, First Edition.
2. **A. E. Eiben, J. E. Smith,** Introduction to evolutionary computing, Springer-Verlag Berlin Heidelberg, 2015, Second Edition.

Reference Books:

1. **K. Deb,** Multi-objective optimization using evolutionary algorithms, Wiley, 2001, First Edition.
2. **A. Q.Badar,** Evolutionary optimization algorithms, CRC Press, 2021, First Edition.

CD1426 **3-0-0 (3)**

Computational Geometry

Pre-Requisites:

Course Outcomes:

CO-1	Understand the new class of problems and algorithms that involve geometry and topology
CO-2	Explore new algorithmic paradigms suitable for geometry and topology problems
CO-3	Apply the techniques to specific application domains
CO-4	Acquire knowledge to pursue independent research in computational geometry

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	1	1	0	-	-	1	-	2	1	1	2	1	3	2
CO-2	1	3	1	1	0	-	-	2	-	2	1	1	2	2	2	2
CO-3	1	1	2	1	0	-	-	-	2	-	1	1	2	1	1	2
CO-4	2	1	2	1	2	-	-	-	2	-	1	1	2	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Voronoi diagram, Delaunay triangulation, Geometric Data Structures, Interval tree, Range tree, Segment tree. Complexes, simplicial complex, Rips complex, alpha complex, homology, Betti numbers, persistence homology, Morse functions, Reeb graph, approximation and fixed parameter algorithms for geometric problems - hitting set and set cover, epsilon nets, epsilon approximations, geometric intersection graphs, geometric discrepancy, clustering.

Learning Resources:

Text Books:

1. **Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars**, Computational Geometry: Algorithms and Applications, Third Edition, Springer, 2011.
2. **Herbert Edelsbrunner and John L. Harer**, Computational Topology: An Introduction, Indian Edition, 2010.
3. Recent literature

CD1428 **3-0-0 (3)**

Dynamical Systems

Pre-Requisites:

Course Outcomes:

CO-1	Identify Autonomous and Nonautonomous Systems.
CO-2	Understand Limit Cycle Motion and Periodic Attractor.
CO-3	Differentiate Dissipative and Conservative Systems.
CO-4	Understand different types of bifurcations.
CO-5	Apply Poincare Bendixson Theory.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	2	1	1	-	-	-	-	-	-	-	2	1	-
CO-2	2	2	2	1	1	1	-	-	-	-	-	-	-	2	1	-
CO-3	2	1	2	-	-	-	-	-	-	-	-	-	-	2	1	-
CO-4	2	2	1	-	-	-	-	-	-	-	-	-	-	2	1	-
CO-5	3	2	3	-	-	-	-	-	-	-	-	-	-	2	1	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Qualitative Features: Autonomous and nonautonomous Systems- Equilibrium Points - Phase space/phase plane and phase trajectories: Stability, Attractors, and Repellers; Classification of equilibrium points- Limit cycle motion - Periodic attractor – Poincare - Bendixson theorem - Higher dimensional systems: Lorenz equations - Quasiperiodic attractor - Poincare map - Chaotic attractor - Dissipative and conservative systems - Hamiltonian systems.

Bifurcations and Onset of Chaos in Dissipative Systems: Saddle-node bifurcation - Pitchfork bifurcation- Transcritical bifurcation - Hopf bifurcation - Discrete dynamical systems - Logistic map - Equilibrium points and their stability- Periodic solutions or cycles - Period doubling phenomenon- Onset of chaos: Sensitive dependence on initial conditions - Lyapunov exponent- Bifurcation diagram - Logistic map- Strange attractor in the Henon map - The period doubling phenomenon - Self-similar structure - Route to chaos.

Chaos in Conservative Systems: Poincare cross-section - Orbits in conservative systems - Regular and irregular trajectories - Canonical perturbation theory: Overlapping resonances and chaos - Periodically driven undamped duffing oscillator - The standard map - Linear stability and invariant curves - Numerical analysis: Regular and chaotic motions.

Characterization of Regular and Chaotic Motions: Lyapunov exponents—Numerical computation of Lyapunov exponents—One-dimensional map—Computation of Lyapunov exponents for continuous-time dynamical systems—Power spectrum and dynamical motion—Autocorrelation—Criteria for chaotic motion.

Learning Resources:

Text Books:

1. **M. Lakshmanan, S. Rajasekar**, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, 2010, First edition,
2. **George F. Simmons**, Differential Equations with Applications and Historical Notes, McGraw- Hill, 2003, Second Edition

Reference Books:

1. **Hirsch, Smale and Devaney,** Differential Equations, Dynamical Systems, and an Introduction to Chaos, Elsevier Academic Press, USA, 2004.
2. **Lawrence Perko,** Differential Equations and Dynamical Systems, Third Edition, Springer- Verlag, 2010.

CD1430 **3-0-0 (3)**

Game Theory

Pre-Requisites:

Course Outcomes:

CO-1	Analyze games based on complete and incomplete information about the players
CO-2	Analyze games where players cooperate
CO-3	Compute Nash equilibrium
CO-4	Apply game theory to model network traffic
CO-5	Analyze auctions using game theory

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	2	3	2	3	1	3	1	3	3	3	1	3	3	2	3
CO-2	3	2	3	2	3	1	3	1	3	3	3	1	3	3	2	3
CO-3	2	3	2	3	2	1	3	1	2	2	2	1	3	2	3	2
CO-4	3	2	3	2	2	1	3	1	3	3	3	1	3	3	2	3
CO-5	3	2	3	2	2	1	3	1	3	3	3	1	3	3	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Non-cooperative Game Theory: Games in Normal Form - Preferences and utility examples of normal-form, Analyzing games: Pareto optimality, Nash equilibrium, Maximin and minimax strategies, dominated strategies, Rationalizability, Correlated equilibrium.

Computing Solution Concepts of Normal-Form Games: Computing Nash equilibria of two-player, zero- sum games, Computing Nash equilibria of two-player, general-sum games, Complexity of computing Nash equilibrium, Lemke–Howson algorithm, Searching the space of supports, Computing Nash equilibria of n- player, general-sum games, Computing maximin and minimax strategies for two-player, general-sum games, Computing correlated equilibria.

Games with the Extensive Form: Perfect-information extensive-form games, Subgame-perfect equilibrium, Computing equilibria, Imperfect-information extensive-form games, Sequential equilibrium **Other Representations:** Repeated games: Finitely repeated games, infinitely repeated games, automata, Stochastic games Bayesian games: Computing equilibria.

Coalitional Game Theory: Transferable Utility, Analyzing Coalitional Games, The Shapley Value, The Core.

Mechanism Design: Strategic voting, unrestricted preferences, Implementation, quasi-linear setting, Efficient mechanisms, Computational applications of mechanism design, Task scheduling, Bandwidth allocation in computer networks.

Auctions: Single-good auctions, Canonical auction families, Bayesian mechanisms, Multiunit auctions, Combinatorial auctions.

Learning Resources:

Text Books:

1. **N. Nisan, T. Roughgarden, E. Tardos, V. Vazirani (Eds.)**. Algorithmic Game Theory. Cambridge University Press, 2007.

2. **Y. Shoham, K. Leyton–Brown,** Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations. Cambridge University Press, 2008.
3. **M.J. Osborne, A. Rubinstein**, A Course in Game Theory. Cambridge, MA: MIT Press, 1994.

Reference Books:

1. **Morton D Davis**, Game Theory: A Nontechnical Introduction, Dover Publications, 2003
2. **Tim Roughgarden**, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016

CD1432 **3-0-0 (3)**

Algorithmic Techniques for Big Data

Pre-Requisites:

Course Outcomes:

CO-1	Introduce the students with Big Data Storage Systems and important algorithms that form the basis of Big Data Processing.
CO-2	Introduces the students to Big storage models.
CO-3	Apply scalable algorithms in real world problems.
CO-4	Sort out the Big Data Issues.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1
CO-2	–	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1
CO-3	3	–	–	–	3	3	–	3	–	–	–	–	1	2	1	2
CO-4	1	3	2	1	2	1	–	–	–	–	–	–	1	2	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Big Data: Introduction to Big Data, The four dimensions of Big Data: volume, velocity, variety, veracity, Drivers for Big Data, Introducing the Storage, Query Stack, Revisit useful technologies and concepts, Real-time Big Data Analytics.

Distributed File Systems: Hadoop Distributed File System, Google File System, Data Consistency.

Big Data Storage Models: Distributed Hash-table, Key-Value Storage Model (Amazon's Dynamo), Document Storage Model (Facebook's Cassandra), Graph storage models.

Scalable Algorithms: Mining large graphs, with focus on social networks and web graphs. Centrality, similarity, a 11-distances sketches, community detection,1 ink analysis, spectral techniques. Map-reduce, Pig Latin, and NoSQL, Algorithms for detecting similar items, Recommendation systems, Data stream analysis algorithms,Clustering algorithms, Detecting frequent items.

Big Data Applications: Advertising on the Web, Web Page Quality Ranking, Mining Social-Networking Group, Human Interaction with Big-Data. Recommendation systems with case studies of Amazon's, Item- to-item recommendations and Netflix Prize, Link Analysis with case studies of the PageRankalgorithm and the spam farm analysis, Crowdsourcing.

Big Data Issues: Privacy, Visualization, Compliance and Security, Structured vs Unstructured Data.

Learning Resources:

Text Books:

1. **Ohlhorst, J. Frank,** Big data analytics: turning big data into big money. Vol. 65. John Wiley & Sons, 2012.

2. **Russom, Philip**, Big data analytics. TDWI best practices report, fourthquarter 19, no. 4 (2011), 1-34,
3. **Marr, Bernard**, Big Data: Using SMART big data, analytics and metrics to make better decisions and improve performance. John Wiley & Sons, 2015.

Reference Books:

1. **LaValle, Steve, Eric Lesser, Rebecca Shockley, Michael S. Hopkins, and Nina Kruschwitz,**. Big data, analytics and the path from insights to value, MIT sloan management review 52, no. 2 (2011): 21-32.
2. **Leskovec, Jure, Anand Rajaraman, and Jeffrey David Ullman**, Mining of massive data sets, Cambridge University Press, 2020.

CD1434 **3-0-0 (3)**

Advanced Theoretical Computer Science

Pre-Requisites:

Course Outcomes:

CO-1	Identify and explain fundamental mathematical constraints for developing algorithms to solve problems in high dimensional space.
CO-2	Develop methods to study how to draw good samples efficiently and how to estimate statistical and linear algebra quantities, with such samples.
CO-3	Apply learning models and algorithms with provable guarantees on learning error and time.
CO-4	Build models to understand and to capture essential properties of large structures, like the web and social networks

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	3	3	2	2	1	-	1	-	-	1	-	-	3	1	2	-
CO-2	2	3	2	1	3	-	-	1	-	1	-	1	3	1	3	-
CO-3	2	2	2	2	3	1	1	-	1	1	-	-	3	3	2	1
CO-4	2	3	3	3	3	1	-	1	1	-	-	1	3	3	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

High-Dimensional Space - The Law of Large Numbers, The Geometry of High Dimensions, Properties of the Unit Ball, Volume of the Unit Ball, Volume Near the Equator, Generating Points Uniformly at Random from a Ball, Gaussians in High Dimension, Random Projection and Johnson-Lindenstrauss Lemma, Separating Gaussians, Fitting a Spherical Gaussian to Data.

Best-Fit Subspaces and Singular Value Decomposition (SVD) - Singular Vectors, Best Rank-k Approximations, Left Singular Vectors, Power Method for Singular Value Decomposition, A Faster Method, Singular Vectors and Eigenvectors, Applications of Singular Value Decomposition, Centering Data, Principal Component Analysis, Clustering a Mixture of Spherical Gaussians, Ranking Documents and Web Pages, Application of SVD to a Discrete Optimization Problem.

Random Walks and Markov Chains - Stationary Distribution, Markov Chain Monte, Metropolis- Hasting Algorithm, Gibbs Sampling, Areas and Volumes, Convergence of Random Walks on Undirected Graphs, Using Normalized Conductance to Prove Convergence, Electrical Networks and Random Walks, Random Walks on Undirected Graphs with Unit Edge Weights, Random Walks in Euclidean Space, The Web as a Markov Chain.

Machine Learning - The Perceptron algorithm, Kernel Functions, Generalizing to New Data, Overfitting and Uniform, illustrative Examples and Occam's Razor, Learning Disjunctions, Occam's, Application: Learning Decision Trees, Regularization: Penalizing Complexity, Online, Online to Batch Conversion, Support-Vector Machines, VC-Dimension, Strong and Weak Learning – Boosting, Stochastic Gradient Descent, Combining (Sleeping) Expert Advice, Deep Learning, Further Current Directions.

Algorithms for Massive Data Problems: Streaming, Sketching, and Sampling - Frequency Moments of Data Streams, Matrix Algorithms using, Sketches of Documents
Clustering - Two General Assumptions on the Form of Clusters, k-Center, Spectral Clustering, Approximation Stability, High-Density Clusters, Kernel Methods, Recursive Clustering based on Sparse Cuts, Dense Submatrices and Communities, Community Finding and Graph Partitioning, Spectral clustering applied to social network graphs

Random Graphs - The G (n; p) Model, Phase Transitions, Giant, Cycles, Phase Transitions for Increasing, Branching Processes, CNF-SAT, Nonuniform Models of Random Growth Models, Small World Graphs Topic Models, Nonnegative Matrix Factorization, Hidden Markov Models.

Graphical Models - Topic Models, An Idealized Model, Nonnegative Matrix Factorization – NMF, NMF with Anchor Terms, Hard and Soft Clustering, The Latent Dirichlet Allocation Model for Topic, The Dominant Admixture, Finding the Term-Topic Matrix, Hidden Markov, Graphical Models and Belief, Bayesian or Belief, Markov Random, Factor, Tree Algorithms, Message Passing in General, Graphs with a Single Cycle, Belief Update in Networks with a Single, Maximum Weight Matching, Warning.

Other Topics - Ranking and Social Choice, Compressed Sensing and Sparse, Applications, Uncertainty Principle

Learning Resources:

Text Books:

1. **Brian Steele, John Chandler, Swarna Reddy**, "Algorithms for Data Science", Springer, 2016
2. **Noga Alon and Joel H Spenser**, "Probabilistic Method", Third Edition,. John Wiley & Sons, 2008.

Reference Books:

1. **Rajeev Motwani and Prabhakar Raghavan**, "Randomized Algorithms", Cambridge University Press, 1995.

CD1436 **3-0-0 (3)**

IoT Security

Pre-Requisites:

Course Outcomes:

CO-1	Ability to Define and implement a security policy.
CO-2	Apply the knowledge to design and build the next generation of smart devices and networked systems.
CO-3	Identify various security issues to detect real-time and capture sensitive data.
CO-4	Understanding of the range of wireless and application protocols that support different IoT application domains.
CO-5	Design or build the reliable, secure system for IoT networks.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	–	1	–	–	2	–	–	–	–	–	–	–	–	–	3	–
CO-2	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–
CO-3	–	–	–	1	–	–	2	–	2	–	–	–	–	–	–	–
CO-4	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–	3
CO-5	–	–	1	–	–	–	–	–	–	–	–	–	3	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to IoT, IoT protocols, Security Requirements, IoT applications and their security/various vulnerabilities, Sensor-based attacks, IoT device-based attacks, Network attacks, attacks against IoT systems (hardware + software) Security issues in SCADA systems, ZIGBEE & BLE, Power analysis attacks, Invasive attacks, Perturbation -attacks, Electromagnetic side-channel attacks, fault injection attack, timing attack, covert channel attacks. M2M Security, RFID Security, Active vulnerability analysis tools, Port scanning, Operating system fingerprinting and version scanning, Penetration testing, Attack surface mapping, Hardware Security, PUF

Privacy Issues of IoT, Trust management in IoT, IoT device authentication, Lightweight authentication techniques in IoT, Blockchain For IoT, Challenges of IoT Addressing Security, Ethics, Privacy, and Laws, Machine Learning-Enabled IoT Security

Learning Resources:

Text Books:

1. **Shancang Li, Li Da Xu**, Securing the Internet of Things", Syngress, Elsevier, 2017.
2. **Fei HU**, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations", CRC Press,2016.

CD1438 **3-0-0 (3)**

Semantic Web

Pre-Requisites:

Course Outcomes:

CO-1	Understand the standards and data formats used in the Semantic Web
CO-2	Comprehend technologies including XML and XSLT
CO-3	Design semantic web meta data and RDF schema
CO-4	Develop ontology programming with Jena API

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	-	-	-	1	-	-	2	-	2	-	-	-	-	1	1
CO-2	-	1	2	-	2	1	2	-	-	-	-	2	-	1	2	1
CO-3	2	1	1	1	2	1	-	1	2	1	2	1	1	1	2	1
CO-4	-	-	1	1	1	2	1	-	1	-	-	1	2	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

The Semantic Web Vision, overview of techniques and standards, Semantic Web Architecture, XML with Document Type Definitions and Schemas, Transformation/Inference rules in XSLT, RuleML and RIF, metadata with RDF (Resource Description Framework); metadata taxonomies with RDF Schema; Ontology languages, Ontology Development using Protege editor, Ontology Querying, Ontology Reasoning and Description Logic (DL), Semantic Web Application Areas, Ontology programming with Jena API, Ontology Engineering.

Learning Resources:

Text Books:

1. **Grigoris Antoniou and Frank van Harmelen**, "A Semantic Web Primer", 1st Edition, MIT Press, 2004.
2. **John Hebeler, Matthew Fisher, Ryan Blace and Andrew Perez-Lopez**, "Semantic Web Programming", 1st Edition, Wiley, 2009.

CD1440 **3-0-0 (3)**

Cyber Security

Pre-Requisites:

Course Outcomes:

CO-1	Understand the cyber security fundamentals.
CO-2	Identify & Evaluate cyber security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios.
CO-3	Design and implement appropriate security techniques and cyber policies to protect computers and digital information.
CO-4	Identify common trade-offs and compromises that are made in the design and development process of Information Systems.
CO-5	Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	-	1	-	-	2	-	2	-	-	-	1	-	-	-	2	-
CO-2	-	-	2	-	1	-	-	-	1	1	1	1	1	-	2	1
CO-3	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	1
CO-4	1	-	-	1	1	1	-	-	-	1	-	2	-	-	2	1
CO-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Cyber Security Fundamentals: Network and Security Concepts-Information Assurance Fundamentals, Basic Cryptography, Symmetric and Asymmetric Encryption, Public Key Encryption, The Domain Name System (DNS), Firewalls, Virtualization, Radio-Frequency Identification.

Threats and vulnerabilities: Types of Threats- Malware, Phishing, Ransomware, Adware and Spyware, Trojan, Virus, Worms, Man-in-the-middle-attack, Scareware, Distributed Denial-Of- Service Attack, Rootkits, click-fraud. Vulnerability-Shellcode, Integer Overflow Vulnerabilities, Buffer Overflows, SQL Injection.

Defense and mitigation measures: Anti-virus scanners, static and dynamic methods, anti- analysis, evading obfuscations and run-time attacks.

Cyber Forensics: Memory and network Forensics for Windows and Linux internals, Forensic tools, OS hardening and RAM dump analysis, data acquisition, data extraction, volatility analyses for OS artifacts and other information. Automated malicious code analysis.

Cybersecurity law and Regulations: Introduction, Cyber Warfare, Deception in the Cyber World, Legal Framework of Cyber Security.

Learning Resources:

Text Books:

1. **James Graham, Richard Howard, Ryan Olson**, "Cyber Security Essentials", CRC Press, 2016.
2. **David Salomon**, Foundations of Computer Security, Springer, 2006.

Reference Books:

1. **MarttiLehto, PekkaNeittaanmäki**, Cyber Security: Analytics, Technology and Automation, Springer, 2015.

CD1442 **3-0-0 (3)**

Soft Computing

Pre-Requisites:

Course Outcomes:

CO-1	Understanding of optimizations problems, comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.
CO-2	Understand the fundamental theory and concepts of neural networks and Identify different neural network architectures, algorithms, applications and their limitations.
CO-3	Apply genetic algorithms and neural networks to solve real world problems.
CO-4	Apply soft computing techniques to solve engineering and other societal problems.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	2	1	2	1	1	-	1	–	1	1	1	-	2	1	2	-
CO-2	2	2	1	1	1	-	-	–	–	1	1	-	2	1	2	-
CO-3	2	2	2	2	1	1	1	–	–	1	1	1	2	1	3	-
CO-4	2	2	2	2	1	1	1	–	–	1	1	1	2	1	3	-

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Overview of course and Basic of Soft Computing, Introduction of Neural Networks, Learning Process and Learning Task, Supervised Learning – Single and Multi – Layer Network, Associative Memory, Self-organizing Maps, Neuro-Dynamics, Hopfield Network, Fuzzy Logic and Systems-Fuzzy Sets and Membership Functions, Operations on Fuzzy Sets, Fuzzification. Fuzzy Numbers- Uncertain Fuzzy Values, Fuzzy Numbers and its L-R representation, Operations on Fuzzy Numbers. Fuzzy Relations, Fuzzy Inference Systems- Architecture of Fuzzy Inference System, Fuzzy Inference Rules and Reasoning, Defuzzification. Applications of Fuzzy Logic, Genetic algorithms and evolutionary computation. Applications of Genetic Algorithms & Hybrid Systems.

Learning Resources:

Text Books:

1. **R.A. Aliev, R.R. Aliev**, Soft Computing and Its Applications, World Scientific Publications, 2001.
2. **Roger Jang, Tsai Sun, Eiji Mizutani**, Neuro-Fuzzy and Soft Computing: A computational Approach to Learning & Machine Intelligence, PHI, 2008.
3. **Simon Haykin**, Neural Network: A Comprehensive Foundation, PHI, 1999.
4. **Kishan Mehtrotra, S. Ranka**, Elements of artificial Neural Networks, Penram International Publishing (India), 2009
5. **Timothy Ross**, Fuzzy Logic with Engineering Applications, 3rd Edition, McGraw-Hill, 2010.
6. **Bart Kosko**, Neural Networks and Fuzzy Systems, PHI, 1994.

CD1444 **3-0-0 (3)**

Randomized Algorithms

Pre-Requisites:

Course Outcomes:

CO-1	Design and analyze efficient randomized algorithms
CO-2	Apply tail inequalities to bound error-probability
CO-3	Analyze randomized algorithms with respect to probability of error and expected running time
CO-4	Analyze approximation algorithms and determine approximation factor

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3	PSO-4
CO-1	1	2	3	–	–	–	2	–	–	–	–	–	1	1	1	1
CO-2	–	3	–	–	–	–	–	–	–	–	–	–	3	2	1	1
CO-3	1	2	3	–	–	–	2	–	–	–	–	–	1	1	1	1
CO-4	3	–	3	–	3	3	–	–	–	–	–	–	–	–	2	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction, Las Vegas and Monte Carlo Algorithms, Computational Model and Complexity Classes, Game Tree Evaluation, The Markov and Chebyshev Inequalities, The Stable Marriage Problem, The Coupon Collectors Problem, The Chernoff Bound, Routing in a Parallel Computer, The Probabilistic Method: Overview, probabilistic analysis, use of indicator random variables, Randomly permuting arrays, Birthday paradox, analysis using indicator random variables, Balls and bins, Streaks, Online hiring problem, Maximum Satisfiability, Expanding Graphs, The Lovasz Local Lemma, Markov Chains, Random Walks on Graphs, Graph Connectivity, Expanders and Rapidly Mixing Random Walks, Pattern Matching, Random Trees, Skip Lists, Hash Tables, Linear Programming, The Min-Cut Problem, Minimum Spanning Trees, The DNF Counting Problem, Maximal Independent Sets, Perfect Matching, The Online approximations paging Problem, Adversary Models and Paging against an Oblivious Adversary, Vertex cover problem, traveling salesman problem with triangle inequality, general traveling salesman problem, set-covering problem, a greedy approximation algorithm, analysis Randomization and linear programming, randomized approximation, subset-sum problem, Absolute approximations, Planar Graph Coloring, MaximumProgramsStoredProblem,NP-hardAbsoluteApproximations$^{\varepsilon}$-approximations, Polynomial time approximations schemes, Scheduling Independent Tasks , 0/1 Knapsack, Fully Polynomial time approximations scheme , Rounding , Interval Partitioning , Separation, probabilistically goodalgorithms.

Learning Resources:

Text Books:

1. **Rajeev Motwani and Prabhakar Raghavan**, Randomized Algorithms, Cambridge University Press, 1995.
2. **J. Hromkovic**, Design and Analysis of Randomized Algorithms, Springer, 2005

SYLLABI
Minor: Mathematics and Computing

CD1M01 **3-0-0 (3)**

Elements of Computational Data Science

Pre-Requisites: **None**

Course Outcomes:

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

Syllabus:

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.

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.

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.

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

Learning Resources:

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.

CD1M02 **3-0-0 (3)**

Introduction to Discrete Mathematical Structures

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply Propositional and first-order logic to determine the statement's validity
CO2	Construct induction proofs involving summations, inequalities, and divisibility
CO3	Implement principles of counting, permutations, and combinatory to solve real-world problems. Formulate and solve recurrence relations
CO4	Determine whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram.
CO5	Develop and analyse the concepts of Boolean algebra

Syllabus:

Mathematical Logic: Connectives, Tautologies, the 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, and inference theory for predicate calculus.

Counting: Basics of counting, Permutations, and combinations - Generalized Permutations and combinations – Pascal's Identity- Vandermonde's Identity, the Principles of Inclusion–Exclusion, Pigeonhole Principle, and Application.

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 and Warshal's algorithm, Partial and total ordering relations.

Boolean Algebra: Chains, Lattices, the principle of duality, basic properties of lattices, distributive and complemented lattices, Boolean lattices and algebras, uniqueness of finite Boolean algebras, Boolean expressions, and functions - Representation and Minimizations of Boolean functions.

Learning Resources:

Text Books:

1. **J. R. Mott, A. Kandel and Baker**, Discrete Mathematics for Computer Scientists, PHI, 2006, Third Edition.
2. **C.L. Liu**, Elements of Discrete Mathematics, McGraw Hill, 2017, Fourth Edition.

Reference Books:

1. **J. P. Tremblay and R. Manohar**, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co., 2017.
2. **Bernand Kolman, Robert C. Busby, Sharon Cutler Ross**, Discrete Mathematical Structures, PHI, 2008, Sixth Edition.

CD1M03 **3-0-0 (3)**

Advanced Data Structures

Pre-Requisites: None

Course Outcomes:

CO1	Understand and implementation of symbol table using hashing techniques
CO2	Apply the concept of Skip Lists for Data Structures and Algorithms.
CO3	Develop and analyze algorithms for red-black trees, B-trees and Splay trees
CO4	Develop algorithms for text processing applications
CO5	Identity suitable data structures and develop algorithms for computational geometry

Syllabus:

Dictionaries: Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.

Hashing: Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing.

Skip Lists: Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists

Trees: Binary Search Trees (BST), AVL Trees

Red Black Trees: Height of a Red Black Tree, Red Black Trees Bottom-Up Insertion, Top-Down Red Black Trees, Top-Down Deletion in Red Black Trees, Analysis of Operations.

2-3 Trees: Advantage of 2-3 trees over Binary Search Trees, Search and Update Operations on 2-3 Trees, Analysis of Operations.

B-Trees: Advantage of B- trees over BSTs, Height of B-Tree, Search and Update Operations on 2-3 Trees, Analysis of Operations.

Splay Trees: Splaying, Search and Update Operations on Splay Trees, Amortized Analysis of Splaying.

Text Processing: String Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem.

Computational Geometry: One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees.

Learning Resources:

Text Books:

1. **Mark Allen Weiss**, "Data Structures and Algorithm Analysis in C++", 2nd Edition, Pearson, 2004.

Reference Books:

1. **Michael T. Goodrich, Roberto Tamassia**, "Algorithm Design", 1st Edition, Wiley, 2006.

CD1M04 **2-0-2 (3)**

Full Stack Development

Pre-Requisites: **None**

Course Outcomes:

CO1	Understand, analyze and build dynamic and interactive web sites.
CO2	Understand current and evolving Web languages for integrating media and user interaction in both front end and back end elements of a Web site.
CO3	Analysis and reporting of web data using web analytics.
CO4	Applying different testing and debugging techniques and analyzing the web site effectiveness.

Syllabus:

HTML: Introduction to HTML, What is HTML, HTML Documents, Basic structure of an HTML document, creating an HTML document, Mark up Tags, Heading-Paragraphs, Line Breaks, HTML Tags. Elements of HTML: Introduction to elements of HTML, Working with Text, Working with Lists, Tables and Frames, Working with Hyperlinks, Images and Multimedia, Working with Forms and controls.

Java Script: Introduction to JavaScript, Basic Syntax, Control Structures, Writing Functions, Working with Arrays, The Document Object Model, Events Handling, Client-side Validation, Form Validation & RegExps, ASP, Perl CGI, & Form Methods, SSI & Cookies, Frames & Windows, mimeTypes, plugins, & Java.

PHP: PHP installation and Introduction, Loops String Functions in PHP, PHP Email Function, PHP Basics, Variables Arrays in PHP with Attributes Date & Time, Image, Uploading File handling in PHP Functions in PHP, Errors handling in PHP.

Python: Introduction to Python, Python basics, Data Types and variables Operators, Looping & Control Structure List, Modules Dictionaries, String Regular Expressions, Functions and Functional Programming, Object Oriented Linux Scripting Environment – Classes, Objects and OOPS concepts, File and Directory Access, Permissions and Controls Socket, Libraries and Functionality Programming, Servers and Clients Web Servers and Client scripting, Exploit Development techniques, Writing plugins in Python, Exploit analysis, Automation Process, Debugging basics, Task Automation with Python

Application using Node JS and MongoDB: Introduction to Node.js; Events; Streams; Modules; Express; Socket.io; Persisting Data. Introduction to MongoDB, Accessing MongoDB from Node JS.

Learning Resources:

Text Books:

1. **Deitel, Deitel and Nieto**, "Internet and Worldwide Web - How to Program", 5th Edition, PHI, 2011.
2. **Bai and Ekedhi**, "The Web Warrior Guide to Web Programming", 3rd Edition, Thomson, 2008.

Reference Books:

1. **Brad Dayley, Brendan Dayley, and Caleb Dayley** , Node.Js, Mongodb and Angular Web Development: The Definitive Guide to Using the Mean Stack to Build Web Applications, 2nd Edition, –Pearson Education, 2018
2. **Robertw. Sebesta**, Programming World Wide Web, 8th Edition –Pearson Education, 2020.

CD1M05 **3-0-0 (3)**

Mathematics for Machine Learning

Pre-Requisites: None

Course Outcomes:

CO1	Improve the skills and knowledge in linear algebra and matrix theory to get more out of machine learning
CO2	Understand the matrix decomposition and dimension reduction algorithms required to build many common machine learning techniques
CO3	Learn the calculus to build machine learning applications
CO4	Learn the basic theoretical properties of optimization problems, for applications in machine learning
CO5	Understand the support vector algorithms required to build many common machine learning techniques

Syllabus:

Linear Algebra Basics: Vector spaces and subspaces, basis and dimensions, linear transformation, four fundamental subspaces.

Matrix Theory- Norms and spaces, eigenvalues and eigenvectors, Special Matrices and their properties, least squared and minimum normed solutions.

Matrix Decomposition Algorithms- SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition.

Dimensions Reduction Algorithms and JCF: Principal component analysis, linear discriminant analysis, minimal polynomial and Jordan canonical form.

Calculus: Basic concepts of calculus: partial derivatives, gradient, directional derivatives, jacobian, hessian, convex sets, convex functions and its properties.

Optimization: Unconstrained and Constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, Steepest descent method, Penalty function method.

Support Vector Machines: Introduction to SVM, Error minimizing LPP, concepts of duality, hard and soft margin classifiers.

Learning Resources:

Text Books:

1. **W. Cheney**, Analysis for Applied Mathematics. New York: Springer Science+Business Medias, 2001.
2. **S. Axler**, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.

Reference Books:

1. **J. Nocedal and S. J. Wright**, Numerical Optimization. New York: Springer Science+Business Media, 2006.
2. **J. S. Rosenthal**, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.

SYLLABI

Honors: Mathematics and Computing

CS5101 **3-0-0 (3)**

Advanced Algorithms

Pre-Requisites: None

Course Outcomes:

CO1	Analyze worst-case running times of algorithms using asymptotic analysis.
CO2	Classify problems into different complexity classes corresponding to deterministic, approximation and parameterized algorithms.
CO3	Analyze the complexity of graph problems for different graph classes.
CO4	Analyze approximation algorithms and determine approximation factor.
CO5	Design and analyze efficient randomized algorithms.

Syllabus:

Average case analysis of algorithms, Correctness of Master Theorem, Selection in Worst Case Linear Time, Large integer multiplications using FFT, Dynamic Programming - Matrix Chain Multiplication Problem, Optimal Binary Search Tree, Linear Algorithm for Domination in Trees, Maximum Cardinality Search and Chordal Graphs, Greedy Algorithm for Optimal Coloring of Chordal Graphs, NP-completeness, Efficient Reduction Proofs via Examples, Domination in Subclasses of Bipartite Graphs and Chordal Graphs, Exact Exponential Algorithm for Domination Problems, Treewidth, Parameterized Complexity Classes, APX-hardness and APX-completeness, Approximation Algorithm for Connected Dominating Set Problem, The Stable Marriage Problem, The Coupon Collector`s Problem.

Learning Resources:

Text Books:

1. **Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest** and Clifford Stein, Introduction to Algorithms, PHI, 2009, Third Edition.
2. **Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran**, Fundamentals of Computer Algorithms, Universities Press, 2011, Second Edition.
3. **Martin Charles Golumbic**, Algorithmic Graph Theory and Perfect Graphs, 2004, Elsevier, Second Edition.
4. **Ton Kloks**, Treewidth: Computations and Approximations, Springer-Verlag, 1994.
5. **Andreas Brandstädt, Van Bang Le and Jeremy P.Spinard**, Graph Classes A Survey : SIAM, 1987.
6. **Herbert S. Wilf, AK Peters**, Algorithms and Complexity, CRC Press, 2002, Second Edition.
7. **Rodney G. Downey and M. R. Fellows**, Parameterized Complexity, Springer, 2012.
8. **Vijay V. Vajirani**, Approximation Algorithms, Springer, 2001.
9. **Rajeev Motwani and Prabhakar Raghavan**, Randomized Algorithms, Cambridge University Press, 1995.

CS5151 **3-0-0 (3)**

Advanced Computer Networks

Pre-Requisites: None

Course Outcomes:

CO1	Analyze computer network architectures and estimate quality of service
CO2	Design application-level protocols for emerging networks
CO3	Analyze TCP and UDP traffic in data networks
CO4	Design and Analyze medium access methods, routing algorithms and IPv6 protocol for data networks
CO5	Analyze Data Center Networks and Optical Networks

Syllabus:

Network Architecture, Performance: Bandwidth and Latency, High Speed Networks, Network-Centric View, Error Detection, Reliable Transmission, Ethernet and Multiple Access Networks, Overlay Networks: Routing Overlays, Peer-to-Peer Networks and Content Distribution Networks, Client-Server Networks, Delay-Tolerant Networks, Switching: Circuit-Switched Networks, Datagram Networks, Virtual-Circuit Networks, Message-Switched Networks, Asynchronous Transfer Mode: Evolution, Benefits, Concepts, Exploring Broadband Integrated Services Digital Network, Layer and Adaptation Layer, IPv4: Address Space, Notations, Classful, Classless, Network Address Translation, Datagram, Fragmentation and Checksum IPv6 Addresses: Structure, Address Space, Packet Format and Extension Headers, ICMP, IGMP, ARP, RARP, Congestion Control and Resource Allocation: Problem, Issues, Queuing, TCP Congestion Control, Congestion-Avoidance Mechanisms and Quality of Service, Internetworking: Intra-Domain and Inter-Domain Routings, Unicast Routing Protocols: RIP, OSPF and BGP, Multicast Routing Protocols: DVMRP, PIM-DM, PIM-SM, CBT, MSDP and MOSPF, Spanning Tree Algorithm, Optical Networking: SONET/SDH Standards, Traffic Engineering: Requirement, Traffic Sizing, Characteristics, Protocols, Time and Delay Considerations, Connectivity, Availability, Reliability and Maintainability and Throughput, Multimedia Over Internet: Transmission, IP Multicasting and VoIP, Domain Name System: Name Space, Domain Name Space, Distribution, Domains, Resolutions and Dynamic Domain Name System, SNMP, Security: IPSec, SSL/TLS, PGP and Firewalls, Datacenter Design and Interconnection Networks.

Learning Resources:

Text Books:

1. **Larry L. Peterson and Bruce S. Davie**, Computer Networks: A System Approach, Fifth Edition, Morgan Kaufmann, Elsevier, 2012.
2. **Behrouz A. Forouzan**, Data Communications and Networking, McGraw Hill, Fifth Edition, 2017.
3. **Chwan-Hwa (John) Wu, J. David Irwin**, Introduction to Computer Networks and Cyber Security, CRC press, Taylor & Francis Group,2014
4. **Andrew S. Tanenbaum, David J. Wetherall**, Computer Networks, Pearson, 5th Edition, 2014.
5. **G. Wright and W. Stevens**, TCP/IP Illustrated, Volume 1 and Volume 2, Addison-Wesley, 1996.
6. **Dayanand Ambawade, Deven Shah, Mahendra Mehra and Mayank Agarwal**, Advanced Computer Network, Dreamtech Press, 2016.
7. **R. Srikant**, The Mathematics of Internet Congestion Control, Springer, 2004.
8. **J. L. Boudec and P. Thiran**, Network Calculus, Springer, 2011.

CS5252 **3-0-0 (3)**

Data Privacy

Pre-Requisites: **None**

Course Outcomes:

CO1	Define differential privacy
CO2	Design techniques to achieve differential privacy for linear queries.
CO3	Design mechanisms for query release problem using online learning algorithms.
CO4	Analyze computational complexity of differentially private mechanisms

Syllabus:

The Promise of Differential Privacy: Privacy-preserving data analysis; Basic Terms: The model of computation, Towards defining private data analysis, Formalizing differential privacy; Basic Techniques and Composition Theorems: Useful probabilistic tools, Randomized response, The laplace mechanism, The exponential mechanism, Composition theorems, The sparse vector technique; Releasing Linear Queries with Correlated Error: An offline algorithm: SmallDB, An online mechanism: private multiplicative weights; Generalizations: Mechanisms via α-nets, The iterative construction mechanism, Connections; Boosting for Queries: The boosting for queries algorithm, Base synopsis generators; When Worst-Case Sensitivity is Atypical: Subsample and aggregate, Propose-test-Release, Stability and privacy; Lower Bounds and Separation Results: Reconstruction attacks, Lower bounds for differential privacy; Differential Privacy and Computational Complexity: Polynomial time curators, Some hard-to-Syntheticize distributions, Polynomial time adversaries; Differential Privacy and Mechanism Design: Differential privacy as a solution concept, Differential privacy as a tool in mechanism design, Mechanism design for privacy aware agents; Differential Privacy and Machine Learning: The sample complexity of differentially private machine learning, Differentially private online learning, Empirical risk minimization; Additional Models: The local model, Pan-private streaming model, Continual observation, Average case error for query release.

Learning Resources:

Text Books:

1. **C. Dwork and A. Roth**, The Algorithmic Foundations of Differential Privacy, now Publishers, 2014.
2. **Charu C. Aggarwal**, Privacy-Preserving Data Mining: Models and Algorithms, 1st Edition, Springer, 2008.
3. Relevant Research Papers

CS5201 **3-0-0 (3)**

Web and Database Security

Pre-Requisites: None

Course Outcomes:

CO1	Identify access control methods for secure web & database application development
CO2	Analyse vulnerabilities in the Web and Database applications.
CO3	Design & Evaluate methods for web & database intrusion detection
CO4	Apply security audit methods
CO5	Design Secure Database schema

Syllabus:

Database Basics: Overview of Relational Model, SQL, Building of database, Manipulation of data; Goals of Database Security, access points of database security, database security levels, and menaces to databases. Database security methods and methodologies, Security controls: flow control, inference control and access control, Database Application Security models – Types of users, access matrix model, access modes model, commonly used application types. Classes of access control: Discretionary access control (DAC), Mandatory access control (MAC) and Role based Access control (RBAC); Discretionary Access Control (DAC) mechanisms such as capabilities, profiles, access control lists, passwords, and permission bits. RBAC based security models features like User role assignment, Support for role relationships and Constraints , Assignable privileges. MAC based security models. Implementing Fine Grained access controls with views , Virtual Private databases: need for VPDs, Implementing VPD using views, The Database Security Design includes the controls that will be implemented to restrict users from accessing information, based on how the information is classified and the security model. HTML Injection and Cross- Site Scripting, Cross-Site Request, Forgery, SQL Injection and Data Store Manipulation, Breaking Authentication Schemes, Abusing Design Deficiencies, Leveraging Platform Weaknesses, Statistical database security; Database privacy – Hippocratic databases.

Learning Resources:

Text Books:

1. **SilvanoCastano, Fugini, Martella, Samarati**, Database Security, Addison Wesley, 1994.
2. **M. Gertz, S. Jajodia**, Handbook of Database Security, Springer, 2008
3. **Ben-Natan, R. B**., Implementing Database Security and Auditing: Includes Examples for Oracle, SQL Server, Db2 Udb, Sybase, Digital Press, 2005
4. **Mike Shema**, Hacking Web Apps Detecting and Preventing Web Application Security Problems, Syngress publications- Elsevier, 2012

MA17003 **3-0-0 (3)**

Functional Analysis

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the nature of Banach spaces.
CO-2	Understand the nature of Hilbert spaces.
CO-3	Prove the open mapping theorem, closed graph theorem and uniform boundedness principle
CO-4	Apply results of this course in solving operator equations.

Syllabus:

Banach spaces: Normed linear spaces - Banach spaces, Definition and some examples -Incomplete normed linear spaces - Bounded linear operators - Hahn-Banach theorem

Dual spaces: Conjugate (or dual) spaces - Natural imbedding of normed linear space N in its second conjugate N** - the open mapping theorem - Closed graph theorem - the conjugate of an operator - The Uniform boundedness principle

Hilbert spaces: Definition and basic properties - Orthogonal complements - orthonormal sets - Bessel's inequality - Riesz representation theorem.

Dual of a Hilbert space: The dual of a Hilbert space - adjoint of an operator - projections and projection theorem

Learning Resources:

Text Books:

1. **George F. Simmons**, Introduction to Topology and Modern Analysis, McGraw Hill Inc., 2004
2. **Erwin Kreyszig**, Introductory Functional Analysis with Applications, John Wiley andsons, 2007

Reference Books:

1. **Balmohan V. Limaye**, Functional Analysis, New Age International, 2017, Revised Third Edition
2. **J. Conway**, A Course in Functional Analysis, Springer, 2007, Second Edition
3. **Casper Goffman and George Pedrick**, A First Course in Functional Analysis, AMS Chelsea Publishing, 1983, Second Edition
4. **Peter D. Lax**, Functional Analysis, Wiley-Interscience, 2002