CURRICULUM & SYLLABI

B.Tech. MATHEMATICS & COMPUTING

Effective from AY: 2024-25

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

Table of Contents

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 stake holders 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

MATHEMATICS

VISION

To be among the best mathematics departments in the country, to build an international reputation as a center of excellence in mathematics and computational research, training, and education, and to inculcate mathematical 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

- To attract motivated and talented students by providing a learning environment where they can learn and develop the mathematical and computational skills needed to formulate and solve real-world problems.
- To foster an environment conducive to quality research and to train principled and highly skilled researchers with clear thinking and determination to meet the dynamic challenges of science, engineering, and education.
- To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes.
- To satisfy the country's human resource and scientific manpower requirements in mathematics through learner-centered contemporary education and research.

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 mathematics and other related interdisciplinary fields.
PEO-2	Facilitate as a deep learner and have progressive careers in teaching, academia, research organizations, national/international laboratories, and industry.
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**	**PEO1**	**PEO2**	**PEO3**	**PEO4**	**PEO5**
To attract motivated and talented students by providing a learning environment where they can learn and develop the mathematical and computational skills needed to formulate and solve real-world problems.	2	3	2	3	2
To foster an environment conducive to quality research and to train principled, highly skilled researchers with clear thinking and determination capable of meeting the dynamic challenges of science, engineering, and education.	3	3	3	2	2
To keep up with the rapid advancements of technology while improving academic standards through innovative teaching and learning processes	2	3	2	2	2
To satisfy the country's human resource and scientific manpower requirements in mathematics through learner centered contemporary education and research.	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Mathematics & Computing

Program Outcomes

PO-1	**Mathematical 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, and demonstrate the knowledge of, and need for sustainable development**.**
PO-8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9	**Individual and team work:** 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 engineering and management principles and apply these to one's own work as a member and leader of a team to manage projects 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 analyse their complexities.
PSO-2	Develop a broad theoretical foundation in mathematics and design and develop interfaces among computing subsystems.
PSO-3	Analyse 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	MA1101	Calculus	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	MA1103	Programming & Data Structures	3-0-0	3
5	BT1161	Biology for Engineers	2-0-0	2
6	MA1105	Programming and Data Structures Lab	0-1-2	2
7	IC1101	EAA-I (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**17**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1102	Design Thinking	0-1-4	3
2	MA1104	Ordinary Differential Equations	3-0-0	3
3	MA1106	Data Structures and Algorithms	3-0-2	4
4	EE1162	Basic Electrical and Electronics Engineering	3-0-0	3
5	MA1108	Elementary Linear Algebra	3-0-0	3
6	MA1110	Discrete Mathematical Structures	3-0-0	3
7	EE1164	Basic Electrical Engineering Lab	0-1-2	2
8	IC1102	EAA-II (Games & Sports / Yoga & Wellness)	0-0-0	0
			Total Credits	**21**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1201	Fourier Series and Partial Differential Equations	3-0-0	3
2	MA1203	Real and Complex Analysis	4-0-0	4
3	MA1205	Computer-Oriented Numerical Methods	3-0-0	3
4	EC1263	Computer Organization and Architecture	3-0-2	4
5	MA1209	Object Oriented Programming with JAVA	3-0-0	3
6	MA1211	Computer-Oriented Numerical Methods Lab	0-1-2	2
7	MA1213	Object Oriented Programming with JAVA Lab	0-1-2	2
			Total Credits	**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1202	Computer Oriented Statistical Methods	3-0-0	3
2	MA1204	Functional Analysis	3-0-0	3
3	MA1206	Design and Analysis of Algorithms	3-1-0	4
4	CS1208	Operating Systems	3-0-0	3
5	MS1262	Business Essentials for Engineers	3-0-0	3
6	MA1210	Probability & Statistics with R Lab	0-1-2	2
7	CS1212	Operating Systems Lab	0-1-2	2
			Total Credits	**20**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1301	Operations Research	3-1-0	4
4	MA1305	Database Management Systems	3-0-0	3
3	CS1305	Computer Networks	3-0-0	3
4	MA1303	Mathematics of Machine Learning	3-0-0	3
5	MA13XX	Professional Elective – I	3-0-0	3
6	MA1383	Fractal Course – I	1-0-0	0.5
7	MA1307	Database Management Systems Lab	0-1-2	2
8	CS1309	Computer Networks Lab	0-1-2	2
			Total Credits	**20.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1302	Deep Learning	3-0-0	3
2	MA1304	Computational Methods for Optimization	3-0-0	3
3	MA1306	Product Development	0-1-4	3
4	MA13XX	Professional Elective – II	3-0-0	3
5	XX13XX	Professional Elective – III	3-0-0	3
6	MA1384	Fractal Course – II	1-0-0	0.5
7	MA1308	Deep Learning Lab	0-1-2	2
8	MA1310	Computational Methods for Optimization Lab	0-1-2	2
			Total Credits	**19.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CS1401	High-Performance Computing	**3-0-0**	**3**
2	XX14XX	Professional Elective – IV	**3-0-0**	**3**
3	XX14XX	Professional Elective – V	**3-0-0**	**3**
4		Open Elective-I	**2-0-0**	**2**
5	CS1403	High-Performance Computing Lab	**0-1-2**	**2**
6	MA1489	Seminar & Technical Writing	**2-0-0**	**2**
7	MA1491	Short-Term Industrial/ EPICS/ Research Experience	**2-0-0**	**2**
8	MA1495	Minor Project	**2-0-0**	**2**
			Total Credits	**19**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	XX14XX	Professional Elective – VI	**3-0-0**	**3**
2	XX14XX	Professional Elective–VII	**3-0-0**	**3**
3	XX14XX	Professional Elective–VIII	**3-0-0**	**3**
4	MA1498	Major Project	**0-0-0**	**6**
		Total Credits		**15**

Professional Elective Courses

Professional Elective-I		
S.No.	**Code**	**Course Title**
1	MA1321	Computational Number Theory
2	MA1323	Graph Theory
3	MA1325	Multivariate Calculus and Measure Theory
4	EC1362	Principles of Signals and Systems

Professional Elective - II & III		
S.No.	**Code**	**Course Title**
1	MA1322	Cryptography and Security
2	MA1324	Finite Element Methods
3	MA1326	Applied Statistical Methods
4	MA1330	Time Series Analysis & Forecasting
5	CS1334	Foundations of Block chain Technology
6	CS1328	Computer Vision and Image Processing
7	CS1324	Advanced Databases
8	BT1322	Biological Computations

Professional Elective-IV, V		
S.No.	**Code**	**Course Title**
1	MA1421	Elliptic Curves
2	MA1423	Dynamical Systems
3	MA1425	Theory of Computation
4	MA1427	Game Theory
5	CS 1421	Cloud computing
6	CS1301	Data Warehousing and Data Mining
7	CS1429	Internet of Things
8	EC1461	Digital Electronics & Microcontrollers

Professional Elective-VI, VII, VIII		
S.No.	**Code**	**Course Title**
1	CS1428	Algorithmic Techniques for Big Data
2	CS1422	Advanced Theoretical Computer Science
3	CS1448	IoT Security
4	CS1452	Semantic Web
5	CS1434	Cyber Security
6	MA1422	Fuzzy Mathematics
7	MA1424	Evolutionary Optimization
8	MA1426	Algebraic Codes for Data Transmission and Storage
9	MA1432	Computational Fluid Dynamics
10	MA1430	Numerical Simulation of Differential Equations
11	EC14**	Microprocessors and Microcontrollers
12	BT1421	Genomic Data Analysis

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1101	Calculus	**3-0-0**	**3**
2	PH1161	Engineering Physics	**3-0-2**	**4**
3	MA1102	Ordinary Differential Equations	**3-0-0**	**3**
4	MA1201	Fourier Series and Partial Differential Equations	**3-0-0**	**3**

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1103	Programming & Data Structures	**3-0-0**	**3**
2	MA1105	Programming and Data Structures Lab	**0-1-2**	**2**
3	BT1161	Biology for Engineers	**2-0-0**	**2**
4	MA1102	Design Thinking	**0-1-4**	**3**
5	EE1162	Basic Electrical and Electronics Engineering	**3-0-0**	**3**

6	EE1164	Basic Electrical Engineering Lab	**0-1-2**	**2**
7	MA1306	Product Development	**0-1-4**	**3**

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	13
Engineering Science	18
Humanities and Social Sciences	6
Program Core	80
Professional Elective	21
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	153

Minor in Mathematics & Computing

S.No.	Code	Course Title	L-T-P	Credits
1	MA26025	Elements of Data Science	**3-0-0**	**3**
2	MA26022	Mathematical Foundations of Computer Science	**3-0-0**	**3**
3	MA27023	Advanced Data Structures	**3-0-0**	**3**
4	MA17026	Inventory, Queueing Theory and Non-Linear Programming	**3-0-0**	**3**
5	MA27029	FVM/FEM for Differential Equations	**3-0-0**	**3**

Honors in Mathematics & Computing

S.No.	Code	Course Title	L-T-P	Credits
1	MA1H01	Java Programming	**3-0-0**	**3**
2	MA1H02	Modelling and Simulation	**3-0-0**	**3**
3	MA1H03	Relational Data Bases	**3-0-0**	**3**
4	MA1H04	Neural Networks	**3-0-0**	**3**
5	MA1H05	Statistical Learning	**3-0-0**	**3**

SYLLABI

B.Tech. Mathematics & Computing

1st Semester

MA1101 **3-0-0 (3)**

Calculus

Pre-Requisites: **None**

Course Outcomes:

CO-1	Find the Taylor series expansion of a function.
CO-2	Find the maxima and minima of functions of several variables.
CO-3	Identify the convergence of an improper integral.
CO-4	Evaluate the surface area and volume of a solid of revolution.
CO-5	Compute the surface area and volume of regions using multiple Integration.

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	-
CO-2	3	2	2	1	-	-	-	-	-	-	-	-	-	2	1	-
CO-3	3	3	2	1	-	-	-	-	-	-	-	-	-	2	1	-
CO-4	3	3	2	1	-	-	-	-	-	-	-	-	-	2	1	-
CO-5	3	3	2	1	-	-	-	-	-	-	-	-	-	2	1	-

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

Syllabus:

Differential Calculus: Taylor's theorem with remainders, Taylor's and Maclaurin's expansions, Curvature, Asymptotes, and Curve tracing.

Functions of Several variables: Partial differentiation, Total differentiation, Euler's theorem and generalization, and Change of variables—Jacobians.

Integral Calculus: Convergence of Improper integrals, Beta and Gamma integrals, Elementary properties of Beta and Gamma integrals, Differentiation under the integral sign. Double and triple integrals, Comparing surface areas and volumes using multiple integrations, Changing variables in double and triple integrals.

Vector Calculus: Vector differentiation - Scalar and vector-valued point functions, Derivatives, Curves, Tangents and length, Level surfaces, Gradient of a scalar field and its geometrical interpretation, Directional derivative, Divergence and Curl of a vector field and their applications, Vector identities; Vector integration - Line integrals, Path independence, Green's theorem in the plane, Surfaces and surface integrals, Divergence theorem of Gauss, Stoke's theorem, Verification and problems based on these theorems.

Learning Resources:

Text Books:

1. **George Thomas, J., Ross L. Finney**, Calculus, Pearson, 1996, 9th Edition.
2. **Dennis G. Zill,** A First Course in Differential Equations with Modeling Applications, Brooks/Cole Cengage Learning, 2009, Ninth Edition

Reference Books:

1. **Sudhir R. Ghorpade and B.V. Limaye,** A Course in Multivariable Calculus and Analysis, Springer, 2009.
2. **Joseph George Coffin**, Vector Analysis: An Introduction to Vector-Methods and Their Various Applications to Physics and Mathematics, John Wiley & Sons, 2018.
3. **G.B. Thomas Jr., M.D. Weir and J.R. Hass, Thomas,** Calculus, Pearson Education, 2009

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

Engineering Physics

Pre-Requisites: None

Course Outcomes:

CO-1	Examine the concepts of Interference, diffraction, and polarization to solve engineering problems.
CO-2	Assess the technological applications of lasers and optical fibers.
CO-3	Apply the quantum mechanical principles for solving engineering problems.
CO-4	Understand the basics of nanomaterials and their engineering applications.
CO-5	Demonstrate the production, detection, and applications of ultrasonic.

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	-	-	-	-	-	-	-	-	3	1		-
CO-2	3	3	1	1	-	-	-	-	-	-	-	-	3	1		-
CO-3	3	3	2	1	-	-	-	-	-	-	-	-	3	1		-
CO-4	3	3	2	1	-	-	-	-	-	-	-	-	3	1		-
CO-5	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 a 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 optical fiber's Numerical aperture, loss, and Acceptance angle.
6. Determination of plank constant by photoelectric effect.
7. Determination of I – V characteristics of the photodiode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using an 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 and charge by using the 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 an ultrasonic interferometer.

Learning Resources:

Text Books:

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

Reference Books:

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

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	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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

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

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

Mechanics of 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.

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.

MA1103 **3-0-0 (3)**

Programming & 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 and multi-cellular organisms.
CO-3	Understand heredity, variation, and the central dogma of life.
CO-4	Apply the concepts of biology to 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	PSO-4
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: The chemical basis of life, Proteins, Nucleic acids, Carbohydrates, Lipids, Membranes and the First cell, inside the cell, Cell cycle, and Division.

Information processing in living systems: 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.

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.

MA1105 **0-1-2 (2)**

Programming and Data Structures Lab

Pre-Requisites: MA1103

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++, Pearson, 2014, Ninth Edition.
2. **Chip Weems,** Programming and Problem Solving with C++, Jones and Bartlett Publishers, 2022, 7th 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.

2nd Semester

MA1102 **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
CO-5	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.

MA1104 **3-0-0 (3)**

Ordinary Differential Equations

Pre-Requisites: None

Course Outcomes:

CO-1	Analyse the existence and uniqueness of solutions for initial value Problems.
CO-2	The General Solution of the Homogeneous second order Equations.
CO-3	Find power series solutions to differential equations.
CO-4	Analyse Homogeneous Linear Systems with Constant Coefficients.
CO-5	Identify Critical Points and Stability for Linear 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	3	2	1	-	2	-	-	-	-	-	-	-	1	2	2	-
CO-2	3	2	1	-	2	-	-	-	-	-	-	-	1	2	2	-
CO-3	3	2	1	-	2	-	-	-	-	-	-	-	1	2	2	-
CO-4	3	2	1	-	2	-	-	-	-	-	-	-	1	2	2	-
CO-5	3	2	1	-	2	-	-	-	-	-	-	-	1	2	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

First Order Equations: Homogeneous Equations, Exact Equations, Integrating Factors, Linear Equations, Reduction of Order, The Method of Successive Approximations, Picard's Theorem (without proof).

Higher Order Linear Equations: The General Solution of the Homogeneous Equation, Equation with Constant Coefficients, The Method of Undetermined Coefficients, The Method of Variation of Parameters.

Systems of First-Order Equations: General Remarks on Systems, Linear Systems, Homogeneous Linear Systems with Constant Coefficients, Nonlinear Systems, Volterra's Prey-Predator Equations.

Special Functions: Ordinary and Regular Singular Points, Power Series Solutions, Series solution of Bessel and Legendre's differential equations – Bessel function of the first kind, Recurrence formulae, generating function, Orthogonality of Bessel functions. Legendre polynomial, Rodrigues's formula, Generating function, Recurrence formula, Orthogonality of Legendre polynomials.

Learning Resources:

Text Books:

1. **G.F. Simmons**, Differential Equations with Applications and Historical Notes, McGraw Hill, 2017, Second edition.
2. **E.A. Coddington**, An Introduction to Ordinary Differential Equations, PHI Learning, 1999
3. **Erwin Kreyszig,** Advanced Engineering Mathematics, Wiley, 2011, Tenth edition.

Reference Books:

1. **P. Hartman**, Ordinary Differential Equations, Birkhaeuser, 1982.
2. **L. Perko**, Differential Equations and Dynamical Systems, Springer-Verlag, 1991.

MA1106 **3-0-2 (4)**

Data Structures and Algorithms

Pre-Requisites: MA1103

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, PHI, 2009, Second Edition.
2. **Mark Allen Weiss**, Data Structures and Algorithm Analysis in C++, Pearson Education, 2006, Third Edition.

Reference Books:

1. **Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran**, Fundamentals of Computer Algorithms, Universities Press, 2011, Second Edition.
2. **Michael T.Goodrich and Roberto Tamassia**, Algorithm Design: Foundations, Analysis and Internet Examples, Wiley-India, 2006, Second 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, 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, 2019-Edition.
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/

MA1108 **3-0-0 (3)**

Elementary Linear Algebra

Pre-Requisites: None

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.

MA1110 **3-0-0 (3)**

Discrete Mathematical Structures

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

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

Basic Electrical Engineering Lab

Pre-Requisites: EE1162

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

MA1201 **3-0-0 (3)**

Fourier series and Partial Differential Equations

Pre-Requisites: MA1102

Course Outcomes:

CO-1	Obtain the Fourier series for a given function.
CO-2	Solve linear and nonlinear first-order partial differential equations.
CO-3	Solve higher-order partial differential equations with constant coefficients.
CO-4	Find canonical forms of second-order partial differential equations.
CO-5	Utilize the knowledge of PDES to solve various physical 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	2	3	2
CO-2	–	3	2	–	–	–	–	–	–	–	–	–	–	2	–	–
CO-3	–	3	2	–	–	–	–	–	–	–	–	–	–	2	–	–
CO-4	3	2	2	1	–	–	–	–	–	–	–	–	2	1	–	–
CO-5	3	2	2	2	–	1	–	–	–	–	–	–	3	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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.

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.

MA1203 **4-0-0 (4)**

Real and Complex 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: 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: Definition and examples, open, closed and bounded sets, Interior, closure and boundary, convergence and completeness, continuity and uniform continuity, connectedness, compactness and Separability, Heine-Borel theorem

Complex Analysis: Review of complex numbers, arguments, roots; Regions in the 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.

MA1205 **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.

EC1263 **3-0-2 (4)**

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.

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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", 8t Edition, Pearson Education, 2010.

Reference Books:

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

MA1207 **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. **Robert Lafore,** Object-Oriented Programming in C++, Sams, 2001, Fourth Edition.
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.

MA1209 **0-1-2 (2)**

Computer-Oriented Numerical Methods Lab

Pre-Requisites: MA1205

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	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:

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 iteration 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.

MA1211 **0-1-2 (2)**

Object Oriented Programming with JAVA Lab

Pre-Requisites: MA1209

Course Outcomes:

CO-1	Introduce the fundamental concepts
CO-2	Provide the basic knowledge of using Java with OOP terminology
CO-3	Learn to write Java Scripts
CO-4	Learn overloading, inheritance
CO-5	Write programs to handle files

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
CO-5	-	2	2	-	2	-	-	-	-	-	-	2	1	-	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

1. **Programs on** 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.

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

3. **Programs on 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.

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

5. **Programs on 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. **Robert Lafore,** Object-Oriented Programming in C++, Sams, 2001, Fourth Edition.
2. **Cay S. Horstmann and G. Cornell,** Core Java, Volume 1-Fundamentals, Pearson, 2013, Ninth Edition. 2. Java: the complete reference, H. Schildt, McGraw Hill, 2011, Seventh 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.

4^{th} Semester

MA1202 **3-0-0 (3)**

Computer Oriented Statistical Methods

Pre-Requisites: None

Course Outcomes:

CO-1	Determine the mean, standard deviation and m^{th} moment of a probability distribution
CO-2	Apply theoretical model to fit the empirical data
CO-3	Differentiate between large and small sample tests
CO-4	Use the method of testing of hypothesis for examining the validity of a hypothesis
CO-5	Estimate the parameters of a population from knowledge of statistics of a sample

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	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-2	2	3	3	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Random variables: Review of probability; Discrete and continuous random variables - Joint probability mass function, Marginal distribution function, Joint density function – Independent random variables - Chebyshev's inequality, Binomial, Poisson, Normal distributions -their Properties. The mean and variance. Fit of a given theoretical model to an empirical data.

Correlation and Regression: Coefficient of correlation, the rank correlation, Covariance of two random variables. Regression- Regression Coefficient, The lines of regression.

Estimation: Definitions of population, sampling, statistic, parameter. Types of sampling, expected values of Sample mean and variance, sampling distribution, Standard error, Parameter estimation- Point estimation and interval estimation

Tests of hypothesis: Null hypothesis, Alternate hypothesis, Type I & Type II errors – critical region, confidence interval, and Level of significance. One sided test, Two -sided test.

Statistical Hypotheis: Test of Equality of means of two samples, equality of sample mean and population mean, Tests of significance difference between sample proportion and population proportion, difference between two sample proportions, difference between two sample proportions. Student t-distribution, its properties; Test of significance sample mean and population mean, difference between means of two small samples, Snedecor's F- distribution and its properties. Test of equality of two population variances, Chi-square distribution, its properties, Chi-square test of goodness of fit. One way ANOVA

Learning Resources:

Text Books:

1. **S.C. Gupta and V.K. Kapur,** Fundamentals of Mathematical Statistics, S.Chand & Sons, New Delhi, 2008.

2. **V.K. Rohatgi and A.K. Md. Ehsanes Saleh,** An Introduction to Probability theory and Mathematical Sciences, Wiley, 2001.

Reference Books:

1. **Richard A. Johnson**, Miller & Freund's Probability and Statistics for Engineers, Pearson, 2018, Ninth Edition.
2. **Sheldon M. Ross,** Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, 2014, fifth edition.

MA1204 **3-0-0 (3)**

Functional Analysis

Pre-Requisites: MA1203

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.

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	2	3	-	2
CO-2	3	3	1	-	-	-	-	-	-	-	-	2	2	3	-	2
CO-3	3	3	1	-	-	-	-	-	-	-	-	2	2	3	-	2
CO-4	3	3	2	-	-	-	-	-	-	-	-	2	2	3	-	2

1 - Slightly; 2 - Moderately; 3 - Substantially

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 and Sons, 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

MA1206 **3-1-0 (4)**

Design and Analysis of Algorithms

Pre-Requisites: **None**

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

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

Operating Systems

Pre-Requisites: **None**

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, 2017, eight edition.
2. **Stephen Rago**, **Richard Stevens,** Advanced Programming in the UNIX Environment, Addison-Wesley Educational Publishers Inc, 2013, third edition.

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

Business Essentials for Engineers

Pre-Requisites: None

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/

MA1210 **0-1-2 (2)**

Probability & Statistics with R Lab

Pre-Requisites: MA1204

Course Outcomes:

CO-1	Manipulate data within R and to create simple graphs and charts used in introductory statistics
CO-2	Perform and interpret different distribution using R
CO-3	Carry out hypothesis testing and calculate confidence intervals.
CO-4	Perform linear regression models for data analysis.
CO-5	To use R in solving a wide range of statistical problems in real world.

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:

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. **Maria Dolores Ugarte , Ana F. Militino , Alan T. Arnholt**, Probability and Statistics with R, CRC Press, 2016, 2nd Edition.
2. **P. Dalgaard**, Introductory Statistics with R, Springer 2008, 2nd Edition.

Reference Books:

1. Michael Akritas, " Probability & Statistics with R for Engineers and Scientists”, CRC Press, 2016, 2nd Edition.

CS1212 **0-1-2 (2)**

Operating Systems Lab

Pre-requisites: CS13 Operating Systems**

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 usingalarm signals.
3. Study p-threads and implement the following: Write a program which shows the performance improvement in using threads as compared with process.(Examples like Matrix Multiplication, Hyperquicksort, Merge sort, Traveling Sales Person problem)
4. Create your own thread library, which has the features of p-thread library by using appropriate systemcalls (UContext related calls). Containing functionality for creation, termination of threads with simpleround 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. **Stephen Rago**, **Richard Stevens,** Advanced Programming in the UNIX Environment, Addison-Wesley Educational Publishers Inc, 2013, third edition.

5^{th} Semester

MA1301 **3-1-0 (4)**

Operations Research

Pre-Requisites: None

Course Outcomes:

CO-1	Formulate a LPP and understand graphical solution
CO-2	Determine the solution of a LPP by simplex methods
CO-3	Find a solution of transportation problem
CO-4	Determine the characteristics of a queuing model
CO-5	Determine the EOQ for an inventory model

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	-	-	-	-	-	-	-	2	1	2
CO-2	3	2	2	1	2	2	-	-	-	-	-	-	-	2	1	2
CO-3	3	3	2	1	2	2	-	-	-	-	-	-	-	2	1	2
CO-4	3	3	2	1	2	2	-	-	-	-	-	-	-	2	1	2
CO-5	3	3	2	1	2	2	-	-	-	-	-	-	-	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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

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

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

Learning Resources:

Text Books:

1. **H.A.Taha** , Operations Research: An Introduction, PHI, Delhi, 2014
2. **H.M.Wagner**, Principles of Operations Research, PHI, Delhi, 2010.
3. **Kanti Swarup, P.K. Gupta, Man Mohan**, Operations Research - Introduction to Management Science, Sultan Chand and Sons, 2019.

Reference Books:

1. **J.C.Pant,** Introduction to Optimization: Operations Research, Jain Brothers, Delhi, 2015.
2. **N.S. Kambo**, Mathematical Programming Techniques, East-West Pub., Delhi, 1999.

MA1303 **3-0-0 (3)**

Database Management Systems

Pre-Requisites: None

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: Purpose of Database systems, Data independence, Data models, Database languages, Data storage, Querying and Time management, Database users and administrators.

Entity-Relation Model: Entities, Entities and relationships, Mapping constraints, E-R diagrams; Extended entity-relationship features: Specialization, Generalization and Aggregation; Design of E-R database scheme.

Relational Model: Structure of relational database, Relational algebra; Extended relational algebra operations; Modifying the database and views; Tuple relational calculus; Domain relational calculus.

Integrity Constraints: Domain constraints, Referential integrity, Assertions, Triggers, Functional dependencies.

Relational Database Design: Pitfalls in relational database design, First, Second, Boyce Codd, Third, Fourth and Fifth normal forms.

Security and Integrity: Security and integrity violations, Transfer of privileges, Authorization on views and schema.

Query Processing: Overview of query processing, Structure of query optimizer.

Learning Resources:

Text Books:

1. **Silberschatz, H.F. Korth, and S. Sudarshan**, Database System concepts, McGraw Hill, NewYork, 2021, Seventh Edition.
2. **R. Ramkrishnan, and J. Gehrke,** Database Management Systems, McGraw Hill, 2014, Third Edition.

Reference Books:

1. **Jeffery D. Ullman,**Principles of Database Systems, Galgotia, 1994, Third Edition.
2. **E. Ramez, N. Shamkant,** Fundamentals of Database System, Pearson, 2017, Seventh Edition.

Other Suggested Readings:

1. https://www.youtube.com/watch?v=IoL9Ve2SRwQ&list=PL3pGy4HtqwD3Ov1J2UBTfsLgxUzUktTAM
2. https://www.youtube.com/watch?v=bGyHqvQW6JY&list=PLwZJjHGjgrZqJ9yQZ-WJb5gBJcKMr9iXP

CS1305 **3-0-0 (3)**

Computer Networks

Pre-Requisites: None

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.

MA1305 **3-0-0 (3)**

Mathematics of Machine Learning

Pre-Requisites: None

Course Outcomes:

CO-1	Improve the skills and knowledge in linear algebra and matrix theory to get more out of machine learning
CO-2	Understand the matrix decomposition and dimension reduction algorithms required to build many common machine learning techniques
CO-3	Learn the calculus to build machine learning applications
CO-4	Learn the basic theoretical properties of optimization problems, for applications in machine learning
CO-5	Understand the support vector algorithms required to build many common machine learning 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	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

MA1307 **0-1-2 (2)**

Database Management Systems Lab

Pre-Requisites: MA1210

Course Outcomes:

CO-1	Create the queries using DDL and DML commands
CO-2	Construct the queries using the relational constraints, joins, set operations, and aggregate functions
CO-3	Implement the integrity constraints on various databases
CO-4	Create queries using various data types
CO-5	Develop the queries using triggers and assertions

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	3	2	2	–	–	–	–	–	–	**3**	**2**	–	**3**
CO-2	2	3	3	3	2	2	–	–	–	–	–	–	**2**	**2**	–	**2**
CO-3	3	2	2	3	2	2	–	–	–	–	–	–	**3**	**2**	–	–
CO-4	2	3	2	3	2	2	–	–	–	–	–	–	**3**	**2**	–	**3**
CO-5	3	3	3	2	2	2	–	–	–	–	–	–	**2**	**3**	–	**3**

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to SQL: DDL, DML, DCL Statements, Built-in Functions and Aggregate Functions, Sub Query, Nested Sub Queries, Modification of the Database.

Intermediate SQL: Join Expressions, Views, Integrity Constraints, SQL Data Types and Schemes, Authorization.

Advanced SQL: Triggers and Assertions. PL/SQL, Data types, Control Structures, Error handling mechanism, Subprograms (procedures and functions), Stored procedures, Data base triggers and exception.

Learning Resources:

Text Books:

1. **Silberschatz, H.F. Korth, and S. Sudarshan**, Database System concepts, McGraw Hill, NewYork, 2021, Seventh Edition.
2. **R. Ramkrishnan, and J. Gehrke,** Database Management Systems, McGraw Hill, 2014, Third Edition.

Reference Books:

1. **Jeffery D. Ullman,**Principles of Database Systems, Galgotia, 1994, Third Edition.
2. **E. Ramez, N. Shamkant,** Fundamentals of Database System, Pearson, 2017, Seventh Edition.

CS1309 **0-1-2 (2)**

Computer Networks Lab

Pre-Requisites: CS13 Computer Networks**

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.

6th Semester

MA1302 **3-0-0 (3)**

Deep Learning

Pre-Requisites: None

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.
CO-5	

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
CO-5	2	3	3	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.

MA1304 **3-0-0 (3)**

Computational Methods of Optimization

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.

Learning Resources:

Textbooks:

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.

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.

MA1306 **0-1-4 (3)**

Product Development

Pre-Requisites: None

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	–	–

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

MA1308 **0-1-2 (2)**

Deep Learning Lab

Pre-Requisites: MA1302

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.

MA1310 **0-1-2 (2)**

Computational Methods for Optimization Lab

Pre-Requisites: MA1304

Course Outcomes:

CO-1	Write a program to solve one-dimensional optimization problems.
CO-2	Write a program to solve unconstrained optimization problems.
CO-3	Write a program to solve constrained optimization techniques.
CO-4	Write a program to solve optimization problems using Penalty Functions.
CO-5	Write a program to solve optimization problems 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	1	–	3	–	–	–	–	–	–	–	–	–	2	2	2	2
CO-2	1	–	3	–	–	–	–	–	–	–	–	–	2	2	2	2
CO-3	1	–	3	–	–	–	–	–	–	–	–	–	2	2	2	2
CO-4	1	–	3	–	–	–	–	–	–	–	–	–	2	2	2	2
CO-5	1	–	3	–	–	–	–	–	–	–	–	–	2	2	2	2

Syllabus:

Write programs for the following methods:

1. Exhaustive Search, Dichotomous Search
2. Interval Halving Method
3. Fibonacci Method, Golden Section Method
4. Random Search Methods
5. Grid Search Method, Univariate Method
6. Powell's Method, Simplex Method.
7. Steepest Descent (Cauchy) Method
8. Conjugate Gradient Method
9. Newton's Method, Marquardt Method
10. Davidon, Fletcher, and Powell (DFP) Method
11. Broyden, Fletcher, Goldfarb, Shanno (BFGS) Method.
12. Rosen's Gradient Projection Method
13. Generalized Reduced Gradient Method
14. Sequential Quadratic Programming
15. Penalty Function Method – Interior and Exterior
16. Augmented Lagrange Multiplier Method

Learning Resources:

Textbooks:

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.

Reference Books:

1. **Mokhtar S. Bazaraa, Hanif D. Sherali, C. M. Shetty**, Nonlinear Programming Theory and Algorithms, Wiley, 2013, Third Edition.

7^{th} Semester

CS1401 **3-0-0 (3)**

High-Performance Computing

Pre-Requisites: CS -Operating Systems, CS** -** Computer Networks

Course Outcomes:

CO-1	Design and analyze the parallel algorithms for real world problems and implement themon 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

Introduction: Implicit parallelism, Limitations of memory system performance, control structure, communication model, physical organization, and communication costs of parallel platforms, Routing mechanisms for interconnection networks, mapping techniques.

Parallel algorithm design: Preliminaries, decomposition techniques, tasks and interactions, mapping techniques for load balancing, methods for reducing interaction overheads, parallel algorithm models.

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.

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.

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.

Reference Books:

1. Joseph Jaja, "An Introduction to Parallel Algorithms", Addison-Wesley, 1992.
2. S G Akl, The Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989.

CS1403 **0-1-2 (2)**

High-Performance Computing Lab

Pre-Requisites: CS1401

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

Syllabus:

Introduction to OpenMP and MPI, Communication primitives, Multitasking, Parallel programming and debugging, Deadlocks, Performance measurement, Problem decomposition on multiprocessor network, Load Balancing.

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

MA1489 **0-0-0 (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
CO-1	-	-	-	2	-	-	3	3	2	3	-	3	-	-	-
CO-2	-	-	-	2	-	-	3	3	2	3	-	3	-	-	-
CO-3	2	3	-	2	-	-	3	3	2	3	-	3	-	2	2

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	15 marks
III	Report	15 marks
IV	Presentation	30 marks
V	Response to questions	25 marks

Evaluation Criteria-CO Mapping

Criteria \ CO	CO-1	CO-2	CO-3
I	X		
II	X		
III		X	
IV			X
V			X

MA1491 **0-0-0 (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
CO-1	3	3	3	3	3	-	-	-	-	-	-	3	3	3	3
CO-2	2	2	2	2	2	-	-	3	3	-	3	3	2	2	2
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.

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

Evaluation Criteria-CO Mapping

Criteria \ CO	CO-1	CO-2	CO-3	CO-4
I	X			
II		X		
III			X	
IV				X
V				X

MA1495 **0-0-0 (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
CO-1	3	3	3	3	3	3	3	3	2	-	-	3	3	3	3
CO-2	-	-	-	-	-	-	-	-	3	2	3	-	-	-	-
CO-3	2	2	2	2	2	3	-	-	3	2	2	3	2	2	2
CO-4	-	-	-	-	-	-	-	-	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.

Criteria	Description	Weightages
I	Identification of Problem Domain	20 marks
II	Study of Existing Systems and establishing clear objectives	20 marks
III	Planning of project and work distribution within the team	10 marks
IV	Proper Documentation and Technical Writing	20 marks
V	Presentation and Response to questions	30 marks

Evaluation Criteria-CO Mapping

CO / Criteria	CO-1	CO-2	CO-3	CO-4
I	X			
II	X			
III		X	X	
IV				X
V				X

8^{th} Semester

MA1498 **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				
CO-2	2	2			1	2	1	1	2	2		3				
CO-3	2	2	3	3	3	2	2	2	2	1	3	2				
CO-4	2	2		3	3				2	2		3				

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real-world contemporary 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 will decide the suitability and worthiness of the project

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

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded 'F' grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

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	
II	Literature Survey	
III	Objectives and Solution Methodology	
IV	Performance of the Task and clarity on the work	
V	Report Preparation	
VI	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

Criteria \ CO	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 midterm review, end semester evaluation, template for report preparation, and plagiarism.

Professional Elective-I

(SEMESTER-V)

MA1321 **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.

MA1323 **3-0-0 (3)**

Graph Theory

Pre-Requisites: None

Course Outcomes:

CO-1	Examine whether the graphs are isomorphic or not
CO-2	Determine whether graphs are Hamiltonian and/or Eulerian
CO-3	Construct minimal spanning trees and shortest paths
CO-4	Determine the matching in a graph and solve the assignment problem
CO-5	Construct planar graphs, colouring of graphs and their 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	–	–	–	–	–	–	–	–	–	2	2	–
CO-2	2	3	2	2	1	2	–	–	–	–	–	–	1	1	1	–
CO-3	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	3	2	2	1	2	–	–	–	–	–	–	1	1	1	–
CO-5	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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

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

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

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

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

Learning Resources:

Text Books:

1. **B. Douglas**. Introduction to Graph Theory, West, Pearson, 2015, Second Edition.
2. **R. Diestel**, Graph Theory, Springer, 2017, Fifth Edition.

Reference Books:

1. **Narsingh Deo**, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall, 1979.
2. **J. A. Bondy and U. S. R. Murty**, Graph Theory, Springer, 2008.

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.

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
CO-1	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-3	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-4	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-5	–	–	–	–	–	–	–	–	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:

2. Robert A. Gable, Richard A. Roberts, Signals and Linear Systems, John Wiley, 1995, 3rd Edition.
3. 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

Professional Elective – II & III

(SEMESTER-VI)

MA1322 **3-0-0 (3)**

Cryptography and Security

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.

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.

MA1324 **3-0-0 (3)**

Finite Element Method

Pre-Requisites: None

Course Outcomes:

CO-1	Formulate a variational problem for a boundary value problem
CO-2	Find the solution of solution of one-dimensional problems
CO-3	Find the solution of two-dimensional problems by rectangular elements
CO-4	Find the solution of two-dimensional problems by triangular elements
CO-5	Solve the time dependent 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	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	–	–	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Calculus of Variations: Introduction, Euler's Equation, Euler Lagrange Equations, Ostrogradsky equation.

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

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

Two dimensional problems: Solution of two-dimensional boundary value problems by linear, quadratic and cubic rectangular, serendipity and triangular shape functions.

Time Dependent Problems: One-dimensional heat and wave equations.

Learning Resources:

Text Books:

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

Reference Books:

1. **O. C. Zienkiewiez, K. Morgan**, Finite Elements and Approximation, John Wiley, 1983.
2. **P. E. Lewis, J. P. Ward,** The Finite Element Method – Principles and Applications, Addison Wesley, 1991.

MA1326 **3-0-0 (3)**

Applied Statistical Methods

Prerequisites: MA1204

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.

MA1328 **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

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. **Changqquan 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.

CS1324 **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.

3-0-0 (3)

CS1328

Computer Vision and Image Processing

Pre-Requisites: MA1101, MA1106

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.

MA1410 **3-0-0 (3)**

Blockchain Technologies

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

BT1322 **3-0-0 (3)**

Biological Computations

Pre-Requisites: BT1161, MA1205

Course Outcomes:

CO-1	Understand the principles of Biological Basics for Computing and Data.
CO-2	Apply biology-based principles to real-world data to derive insights.
CO-3	Analyse Biology based principles to real-world data for deriving insights.
CO-4	Analyse real-world data based on biology-based algorithms toward optimal solutions.
CO-5	Develop mathematical models and perform simulation and analysis for real-world data.
CO-6	Design Biology based programming and algorithms for real-world 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	2	–	–	2	1	1	1	–	1	–	–	–	1	–	–
CO-2	1	2	–	–	2	2	1	1	–	1	–	–	–	1	–	–
CO-3	1	2	–	3	2	3	2	1	–	3	–	–	–	3	–	–
CO-4	1	2	3	3	2	3	2	1	1	3	–	–	2	3	–	–
CO-5	1	2	3	1	2	2	3	1	1	3	–	–	2	1	–	–
CO-6	1	2	3	1	2	2	3	1	1	3	–	–	2	1	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Biological Computation: The influence of biology on mathematics – historical examples, biological introduction, modern science simulations, Cellular Automata: biological background, the "game of life", general definition of cellular automata, one dimensional automata, examples of cellular automata, comparison with a continuous mathematical model, computational universality, self-replication, summary, and exercises.

Evolutionary Computation: Evolutionary biology and evolutionary computation, genetic algorithms, example applications, analysis of the behavior of genetic algorithms, Lamarckian evolution, genetic programming, and a second look at the evolutionary process. Artificial Neural Networks: biological background, learning, artificial neural networks, the perceptron, learning in a multi-layered network, associative memory, unsupervised learning, summary, and exercises.

Molecular Computation: Biological background, computation using DNS, enzymatic computation, the never-ending story: additional topics at the interface between biology and computation, swarm intelligence, artificial immune systems, artificial life, systems biology, Dynamic modelling of biological systems using ODE and PDE, Fibonacci series application, rhythmic phenomena modelling, prey predatory models, summary.

Learning Resources:

Text Books:

1. **Ehud Lamm, Ron Unger,** Biological Computation, CRC Press, 2011, first edition.
2. **G.K. Suraishkumar,** Biology for Engineers, Oxford University Press, 2019, first edition.

Reference Books:

1. **Xin-She Yang,** Nature Inspired Optimization Algorithms, Elsevier, 2014, first edition.
2. **Brian P Ingalls,** Mathematical modeling in systems biology: An Introduction, MIT Press, 2022, first Edition.

Professional Elective – IV & V
(SEMESTER-VII)

MA1421 **3-0-0(3)**

Elliptic Curves

Pre-Requisites: None

Course Outcomes:

CO-1	Know the basic arithmetic of elliptic curves
CO-2	Understand the concept of torsion points and pairings in elliptic curves
CO-3	Compute the order of a point and the order of the group of points in elliptic curves over finite fields
CO-4	Apply the elliptic curve method for factorization and primality testing
CO-5	Learn about elliptic curves over rational and complex 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	–	–	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:

Basic theory and tools: Weierstrass Equations; Group law on elliptic curves; Introduction to projective geometry; projective space and the point at infinity; other equations for Elliptic curves and other coordinate systems; the j-invariant; elliptic curves in characteristic 2; Endomorphisms, Frobenius map; Singular curves; Elliptic curves mod n; Torsion points; Division polynomials; Weil pairing; Tate-Lichtenbaum pairing.

Elliptic curves over Finite Fields: Finding rational points on elliptic curves over finite fields; Frobenius endomorphism; Hasse theorem; Baby step, Giant step for finding order of a point; Schoof's algorithm for finding order of the group of points; supersingular curves.

Applications: Bilinear pairings; Cryptosystems based on Bilinear Pairings; Lenstra's factorization algorithm using elliptic curves; Primality testing using elliptic curves.

Number theoretic perspective: An introductory treatment of the topics - Elliptic curves over $\mathbb{Q}$, Elliptic curves over $\mathbb{C}$, Divisors, Isogenies.

Learning Resources:

Text Books:

1. **Lawrence C. Washington**, Elliptic Curves: Number Theory and Cryptography, Chapman & Hall/CRC, 2008, Second Edition.
2. **Joseph H. Silverman**, The Arithmetic of Elliptic Curves, Springer, 2009, Second Edition.

Reference Books:

1. **Neal Koblitzm**, Introduction to Elliptic Curves and Modular Form, Springer, 1984, Second Edition.
2. **Anthony W. Knapp**, Elliptic Curves, Princeton University Press, 1992.
3. **Dan Boneh** and **Victor Shoup,** A Graduate Course in Applied Cryptography, version 0.6 (Jan. 2023) available at http://toc.cryptobook.us/

MA1423 **3-0-0 (3)**

Dynamical Systems

Pre-Requisites: MA1102

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.

MA1425 **3-0-0 (3)**

Theory of Computation

Pre-Requisites: None

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.

MA1427 **3-0-0 (3)**

Game Theory

Pre-Requisites: None

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

CS1421 **3-0-0 (3)**

Cloud Computing

Pre-Requisites: CS13-Computer Networks, CS13**-Operating Systems**

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.
CO-6	Exploring advanced cloud computing topics and tools.

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

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

1. 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.

CS1301 **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

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.

CS1429 **3-0-0 (3)**

Internet of Things

Pre-Requisites: MA1104, MA1208

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.

EC1461 **3-0-0 (3)**

Digital Electronics and Microcontrollers

Pre-requisites: None

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

CO1	Understand the concepts of Number system and Boolean algebra
CO2	design of combinational and sequential logic circuits
CO3	Understand architecture and instruction set of 8051 microcontrollers
CO4	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
CO-1	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-2	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-3	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-4	–	–	–	–	–	–	–	–	2	–	3	2	–	–
CO-5	–	–	–	–	–	–	–	–	2	–	3	2	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

Professional Elective – VI, VII, VIII
(SEMESTER-VIII)

CS1422 **3-0-0 (3)**

Advanced Theoretical Computer Science

Pre-Requisites: None

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.

CS1428 **3-0-0 (3)**

Algorithmic Techniques for Big Data

Pre-Requisites: None

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.

CS1434 **3-0-0 (3)**

Cyber Security

Pre-Requisites: None

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.

CS1448 **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.

Reference Books:

1. Fei Hu, Security and Privacy in Internet of Things (IoTs) Models, Algorithms, and Implementations", CRC Press, 2016.

CS1452 3-0-0 (3)

Semantic Web

Pre-Requisites: None

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.

MA1422 **3-0-0 (3)**

Fuzzy Mathematics

Pre-Requisites: None

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

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).

MA1424 **3-0-0 (3)**

Evolutionary Optimization

Pre-Requisites: None

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.

MA1426 **3-0-0 (3)**

Algebraic Codes for Data Transmission and Storage

Pre-Requisites: MA1106, MA1110

Course Outcomes:

CO-1	Use the main algebraic tools in coding theory.
CO-2	Understand the structure of cyclic, BCH, and RS codes algebraically to harness their power in applications.
CO-3	Realize the capacity-achieving aspect of LDPC codes and their applications.
CO-4	Understand the encoding and decoding of polar codes and their applications.
CO-5	Applying the concepts of cyclic codes in realizing its applicability as DNA codes for data storage and computing

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	-	-	-	-	-	2	2	2	-	3
CO-2	3	3	3	-	1	1	-	-	-	-	-	2	2	2	-	3
CO-3	3	3	3	-	1	1	-	-	-	-	-	2	2	2	-	3
CO-4	3	3	3	-	1	1	-	-	-	-	-	2	2	2	-	3
CO-5	3	3	3	-	1	1	-	-	-	-	-	2	2	2	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Codes: Review of linear codes, generator and parity check matrices, encoding and decoding.

BCH and RS Codes: Finite field arithmetic, Shift registers, Cyclic Codes, BCH codes, Reed-Solomon Codes, Encoding and decoding algorithms; GRS codes, Concatenated codes.

LDPC Codes: Low-density parity-check codes - error correction using parity checks, almost linear-time encoding of LDPC codes, Repeat-accumulate codes; decoding – message passing, bit-flipping decoding, sum-product decoding.

Polar Codes: Encoding of polar codes – Arikan Transforms, reliability sequence; Successive cancellation decoding and list decoding.

DNA Codes: DNA code construction and bounds – reverse and reverse-complement codes, GC-content codes, similarity-based codes.

Learning Resources:

Text Books:

1. **Todd K. Moon**, Error Correction Coding: Mathematical Methods and Algorithms, John-Wiley & Sons, 2005.
2. **Sarah J. Johnson**, Iterative Error Correction: Turbo, Low-Density Parity-Check and Repeat Accumulate Codes, Cambridge University Press, 2010, 3rd Edition.
3. **Orhan Gazi**, Polar Codes: A Non-trivial Approach to Channel Coding, Springer, 2019.
4. **Zoya Ignatova, Israel Martinez-Perez, and Karl-Heinz Zimmermann**, DNA Computing Models, Springer, 2008.

Reference Books:

1. **Elwyn Berlekamp**, Algebraic Coding Theory, World Scientific, 2015.
2. **Ron M. Roth**, Introduction to Coding Theory, Cambridge University Press, 2007.

MA1432 **3-0-0 (3)**

Computational Fluid Dynamics

Pre-Requisites: None

Course Outcomes:

CO-1	Classification of the physical behaviour of governing equations.
CO-2	Understand the effect of turbulent fluctuations on the properties of the mean flow.
CO-3	Handle the errors and uncertainty in CFD modelling.
CO-4	Differentiate DNS, LES, and subgrid-scale models in turbulence flow.
CO-5	Simulate the flow in complex geometries using unstructured grids.

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	3	2	3	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-3	3	1	2	–	–	2	–	–	–	–	–	–	–	–	–	–
CO-4	2	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	3	–	–	1	–	–	–	–	–	–	–	–	–	–

Syllabus:

Basics of computational fluid dynamics: Governing equations of fluid dynamics – Continuity, Momentum, and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD – Elliptic, Parabolic and, Hyperbolic equations.

Finite difference methods: Mixed derivatives – Accuracy - Finite difference formulation – Explicit and Implicit schemes – von Neumann stability analysis – schemes for Parabolic, Elliptic, and Hyperbolic equations – Schemes for Burger's equation.

Coordinate transformation and boundary conditions: Arbitrary geometries, Determination of Jacobians and Transformed equations – Applications of Neumann Boundary Conditions. Artificial compressibility method – Pressure Correction method (Self-Implicit method).

Nonlinear Equations: Euler equations - Quasilinearization–eigenvalues and compatibility relations – Characteristic variables – Central schemes with combined space and time discretization, Nonlinear problems - convection dominated flows, Linearized Burger's equations.

Learning Resources:

Text Books:

1. **T. J. Chung,** Computational Fluid Dynamics, Cambridge Univ., Press, 2003.
2. **C.A.J. Fletcher,** Computational Techniques for Fluid Dynamics, Springer-Verlag, Berlin,1991, Volumes: I and II.

Reference Books:

1. **K. Muralidhar and T. Sundarajan** Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2003.
2. **W. F. Ames,** Numerical Method for Partial Differential Equation, Academic Press, 2014.

MA1430 **3-0-0 (3)**

Numerical Simulation of Differential Equations

Pre-Requisites: None

Course Outcomes:

CO-1	Apply the explicit and implicit multistep methods to solve the linear and non-linear initial value problems in ordinary differential equations.
CO-2	Apply the cubic splines method to solve the two-point boundary value problems in ordinary differential equations.
CO-3	Apply the iterative schemes to finite difference equations.
CO-4	Find the numerical solution of the heat equation, wave equation and the Laplace equation in one dimensional and 2-dimensional space using the finite difference methods.
CO-5	Analyse the stability, convergence and the error analysis of the finite difference methods

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	–	3	2	–	2	–	–	–	–	1	1	2	2
CO-2	3	1	1	–	3	2	–	2	–	–	–	–	1	1	2	2
CO-3	3	1	1	–	3	2	–	2	–	–	–	–	1	1	2	2
CO-4	1	2	2	1	2	2	–	2	–	–	–	–	2	1	1	1
CO-5	1	2	–	–	–	–	–	–	–	–	–	–	–	–	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis Linear and nonlinear boundary value problems, Quasilinearization and Shooting methods.

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

Partial Differential Equations: Classification of partial differential equations, Finite difference approximations for partial derivatives.

Parabolic equations: finite difference schemes for parabolic equations: Schmidt's two level, Multi-level explicit methods, Crank-Nicolson's two level, Multi-level implicit methods, Dirichlet's problem, Neumann problem, Mixed boundary value problem.

Hyperbolic Equations: Explicit methods, Implicit methods, One space dimension. two space dimensions, ADI methods.

Elliptic equations: Laplace equation, Poisson equation, Iterative schemes, Dirichlet's problem, Neumann problem, Mixed boundary value problem, ADI methods.

Learning Resources:

Text Books:

1. **M. K. Jain,** Numerical Solution of Differential Equations, Wiley Eastern, Delhi, 2018, Fourth Edition.
2. **M. K. Jain, S. R. K. Iyengar and R. K. Jain,** Computational Methods for Partial Differential Equations, Wiley Eastern, 2016.

Reference Books:

1. **G. D. Smith,** Numerical Solution of Partial Differential Equations, Oxford University Press, 2004.
2. **S. S. Sastry**, Introductory Methods of Numerical Analysis, PHI, 2012, Fifth Edition.

EE1410 **3-0-0 (3)**

Microprocessors and Microcontrollers

Pre-Requisites: **None (Digital System design)**

Course Outcomes:

CO-1	Understand the evolution of microprocessors and microcontrollers and its architectures.
CO-2	Understand the evolution and architectures of ARM processors.
CO-3	Analyze and understand the instruction set and development tools of ARM.
CO-4	Understand the architectural features of ARM cortex M4 microcontrollers.
CO-5	Understand the exception, interrupts and interrupt handling schemes.
CO-6	Understand the hardware and interfacing peripheral devices to ARM cortex M4

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	1	2	2	–	–
CO-2	-	3	-	-	-3	-	-	-	1	-	2	1	2	2	–	–
CO-3	-	3	-	-	-	-	-	-	1	-	2	1	2	2	–	–
CO-4	-	2	-	-	3	-	-	-	1	-	2	1	2	2	–	–
CO-5	-	2	-	3	-	-	-	1	-	-	-	-	-		–	–
CO-6	2	2	-	-	-	-	-	-	-	-	-	-	-			

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

Syllabus:

Introduction to Microprocessors and Microcontrollers: Evolution and introduction of 80X86 microprocessor, Architecture of 8086, Memory organization, 8086 system connections and timing. Overview of 8051 microcontroller, Architecture, Instruction set and addressing modes, programming of I/O Ports, Interrupts, timer/ counter and serial communication.

Introduction to ARM Processors: Introduction to ARM processors, Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor‘s architecture, Programmer‘s model, Special registers, Operation Modes.

ARM Cortex-M4 programming: Assembly basics, Instruction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations, Cortex-M4-specific instructions,Thumb2 instructions, Keil Microcontroller Development Kit for ARM, Typical program compilation flow, Sample arithmetic and logical assembly language programs.

ARM cortex-M4 Memory Systems and interrupts: Overview of memory system features, Memory map, Memory access attributes and permissions, Data alignment and unaligned data access support, Bit-band operations, Overview of exceptions and interrupts, Exception types, Overview of interrupt management, Definitions of priority, Vector table and vector table relocation, Software interrupts, Exception Handling.

Cortex-M4 Implementation and applications: Detailed block diagram, Bus interfaces on cortex-M4, External PPB interface, typical connections, reset types and signals. Getting started with µVision. Applications: Flashing of LEDS using Shift Register, Interfacing stepper motor, Interfacing temperature sensor, Interfacing ADC, Interfacing Real Time Clock, Interfacing of Analog Key pad.

Learning Resources:

Text Books:

1. **Joseph Yiu**, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications, 2013, 3rd Edition.
2. **Ata Elahi-Trever Arjeski,** ARM Assembly language with hardware experiment‖, Springer Int. Publishing, 2015.
3. **Steve Furber** , ARM system on chip Architecture‖, Pearson Publications, Second Edition,2000.
4. D. V. Hall. Microprocessors and Interfacing, TMGH, 2017, Third Edition.

Reference Books:

1. **James A. Langbridge**, Professional Embedded ARM Development (Wrox: Programmer to Programmer), Wrox, 2014.
2. **William hohl and Christoper Hinds**, ARM assembly language fundamentals and Techniques, CRC, 2015, 2nd Edition.
3. **M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay**, The 8051 Microcontroller and Embedded Systems, Pearson, 2007, 2nd Edition.

BT1421 **3-0-0 (3)**

Genomic Data Analysis

Pre-Requisites: Cell Biology, Molecular Biology, Biostatistics

Course Outcomes:

CO-1	Identify the genomics technologies to generate different genomics data.
CO-2	Understand the use of different types of genomics data for biomedical applications.
CO-3	Apply the mathematical and statistical tools for analyzing the genomics data.
CO-4	Categorize human disease through genomics.

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	-	-	-	-	-	-	-	3	-	2	3
CO-2	3	2	-	3	1	-	-	-	-	-	-	-	3	-	-	3
CO-3	3	2	-	3	2	-	-	-	-	-	-	-	3	-	2	3
CO-4	3	2	-	3	3	-	-	-	-	-	-	-	3	-	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Genomics data and Technology: Introduction to genomics and transcriptomics data, whole-genome sequencing, Genomic data preprocessing, data scaling (TPM, FPKM, RSEM), mapping, RNAseq, copy number variation (CNV), alternative splicing, methylation data analysis, non-coding RNA, Expression quantitative trait loci (eQTL), Splicing Quantitative Trait Loci (sQTL), SNP and genome-wide association studies (GWS).

Statistics in Genomics data analysis: Variables in genomics data; Statistical test: p-value; False discovery rate; hypergeometric test; chi-square test; fisher's exact test; regression analysis: Ridge, Lasso, elastic net; unsupervised and supervised learning techniques for multivariate data, confusion matrix, receiving operating curve.

Genomic data in phenotype prediction: Concept of genotype and phenotype: omnigenic model; genomics relationship matrix (GRM), functional analysis of genomic data, cancer genomics, multi-omics approaches in phenotype prediction, genomics data to molecular network, case studies.

*Along with theory classes, Hands-on sessions will be conducted.

Learning Resources:

Text Books:

1. **Sorin Draghici,** Statistics and Data Analysis for Microarrays Using R and Bioconductor, (Chapman & Hall/CRC Computational Biology Series Book 4), 2nd Edition.
2. **Motulsky H,** Intuitive Biostatistics, Oxford University Press, 2009, 2nd Edition.

Reference Books:

1. **Michael R. Barnes,** Bioinformatics for Geneticists: A Bioinformatics Primer for the Analysis of Genetic Data, 2007, Wiley, 2nd Edition.
2. **Kim, Ju Han,** Genome Data Analysis, 2019, Springer, 1st Edition.

Other Suggested Readings:

1. Biological data sciences in genome research, Genome Research. 2015. 25: 1417-1422 (https://genome.cshlp.org/content/25/10/1417.full)
2. Genome-wide association studies of cancer: current insights and future perspectives. Nature Reviews Cancer 17, 692–704 (2017) (https://www.nature.com/articles/nrc.2017.82)
3. Statistical and integrative system-level analysis of DNA methylation data, Nature Reviews Genetics volume 19, pages129–147 (2018) (https://www.nature.com/articles/nrg.2017.86)

SYLLABI

Minor: Mathematics and Computing

MA26025 **3-0-0 (3)**

Elements of Data Science

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze the basics of data science
CO-2	Apply Principal Component Analysis
CO-3	Analyze spectral clustering
CO-4	Compute dimension reduction and clustering of random graphs
CO-5	Apply approximation 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	3	–	2	3	–	2	–	–	–	–	–	–	–	–	–	–
CO-2	3	–	2	2	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	–	2	3	–	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	–	2	2	–	1	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

MA26022 3-0-0 (3)

Mathematical Foundations of Computer Science

Pre-Requisites: None

Course Outcomes:

CO-1	Apply Propositional and first-order logic to determine the statement's validity
CO-2	Construct induction proofs involving summations, inequalities, and divisibility
CO-3	Implement principles of counting, permutations, and combinatory to solve real-world problems. Formulate and solve recurrence relations
CO-4	Determine whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram.
CO-5	Develop and analyse the concepts of Boolean algebra

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	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	1	2	–	2	–	3	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	–	1	–	**1**	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

MA27023 **3-0-0 (3)**

Advanced Data Structures

Pre-Requisites: MA2603

Course Outcomes:

CO-1	Understand and implementation of symbol table using hashing techniques
CO-2	Apply the concept of Skip Lists for Data Structures and Algorithms.
CO-3	Develop and analyze algorithms for red-black trees, B-trees and Splay trees
CO-4	Develop algorithms for text processing applications
CO-5	Identity suitable data structures and develop algorithms for 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	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-2	3	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	3	3	–	3	–	2	–	–	–	–	–	–	–	–	–	–
CO-5	2	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

MA17026 **3-0-0 (3)**

Inventory, Queuing Theory and Non-Linear Programming

Pre-Requisites: **None**

Course Outcomes:

CO-1	Determine the characteristics of a queuing model
CO-2	Determine the EOQ for a deterministic inventory model
CO-3	Determine the EOQ for a stochastic inventory model
CO-4	Determine the solution of a CNLPP
CO-5	Determine the solution of a QPP

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	–	–	–	–	–	–	–	–	–	–
CO-2	3	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–
CO-5	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–

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

Syllabus:

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.

Inventory control: Inventory control for single commodity - Deterministic inventory models (without and with shortages) - Probabilistic inventory (both discrete and continuous) control models.

Nonlinear programming problem: Unconstrained NLPP, Constrained NLPP - Lagrange's multipliers method - Convex NLPP, Kuhn-Tucker conditions (including the proof) - Quadratic programming problem (Wolfe's method).

Learning Resources:

Text Books:

1. H. A. Taha, Operations Research: An Introduction, PHI, Delhi, 2014, Tenth Edition.
2. H. M. Wagner, Principles of Operations Research, PHI, Delhi, 2010, Second Edition.

Reference Books:

1. J. C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, Delhi, 2015, Seventh Edition.
2. Kanti Swarup, P.K. Gupta, Man Mohan, Operations Research - Introduction to Management Science, Sultan Chand and Sons, 2019, Thirteenth Edition.

MA27029 **3-0-0 (3)**

Finite Element and Finite Volume Methods

Pre-Requisites: None

Course Outcomes:

CO-1	Formulate a variational problem for a boundary value problem
CO-2	Find the solution of solution of boundary value problems using FEM
CO-3	Identify the properties of discretization schemes.
CO-4	Solve convective problems using upwind, QUICK and hybrid schemes
CO-5	Solve convective problems using upwind, QUICK and hybrid schemes

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	1	–	–	–	–	–	–	–	–	–	–	–
CO-2	–	3	1	2	1	–	–	–	–	–	–	–	–	–	–	–
CO-3	1	2	–	3	2	–	–	–	–	–	–	–	–	–	–	–
CO-4	–	3	–	2	2	–	–	–	–	–	–	–	–	–	–	–
CO-5	–	3	2	2	2	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

Central differencing scheme, Upwind differencing scheme, Hybrid differencing scheme, Power-law scheme. Properties of discretisation schemes: Conservativeness - Boundedness – Transportiveness. Quadratic upwind differencing scheme: the QUICK scheme - Stability problems of the QUICK scheme and remedies - Generalisation of upwind- biased discretisation schemes - Total variation and TVD schemes - Criteria for TVD schemes - Flux limiter functions - Implementation and Evaluation of TVD schemes. Finite Volume solution of 1-D and 2-D problems

Learning Resources:

Text Books:

1. H. Versteeg and W. Malalasekera, An introduction to CFD: The Finite Volume Method, Pearson, 2007, Second Edition.
2. I. J. Chung, Finite Element Analysis in Fluid Dynamics, McGraw-Hill International Book Company, 2007, Digitized Version, First Edition.
3. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill, 2020, Fourth Edition.

Reference Books:

1. P. E. Lewis and J. P. Ward, The Finite Element Method - Principles and Applications, Addison Wesley, 1991, First Edition.
2. F. Moukalled, L. Mangani, M. Darwish, The Finite Volume Method in Computational Fluid Dynamics An Advanced Introduction with OpenFOAM® and Matlab, Springer, 2015, First Edition.

SYLLABI

Honors: Mathematics and Computing

MA1H01 **3-0-0 (3)**

Java Programming

Pre-Requisites: None

Course Outcomes:

CO-1	Introduce the fundamental concepts of Java
CO-2	Provides a foundation for using basic concepts in Java
CO-3	Learn to write Java Scripts
CO-4	Explore various Exception-handling mechanisms
CO-5	Provide the basic knowledge of using Java with OOP terminology

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	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-3	2	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	1	2	1	–	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	1	1	1	–	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Java Basics: History of Java, Java buzzwords, comments, data types, variables, constants, scope and lifetime of variables, operators, operator hierarchy, expressions, type conversion and casting, enumerated types, control flow-block scope, conditional statements, loops, break and continue statements, simple java program, arrays, input and output, formatting output.

Inheritance: The inheritance concept, benefits of inheritance, Super classes, and subclasses, Member access rules, Inheritance hierarchies, super use, preventing inheritance: final classes and methods, casting, polymorphism—dynamic binding, method overriding, abstract classes and methods, and 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, Using java.io.

Networking: Networking in Java – Introduction, Manipulating URLs, Ex. Client/Server Interaction with Stream Socket Connections, Connectionless Client/Server Interaction with Datagrams, Using java.net.

Exception handling: Dealing with errors, benefits of exception handling, the classification of exceptions-exception hierarchy, checked exceptions and unchecked exceptions, usage of try, catch, throw, throws, and finally, rethrowing exceptions, exception specification, built-in exceptions, creating own exception subclasses, Guidelines for proper use of exceptions.

Learning Resources:

Text Books:

1. Cay S. Horstmann and G. Cornell, Core Java, Volume 1-Fundamentals, Pearson, 2013, Ninth Edition.

2. H. Schildt, Java: the complete reference, McGraw Hill, 2022, 12th Edition.

Reference Books:

1. D.S. Malik, Java Programming, Cengage Learning, 2009.
2. E. Balagurusamy, Programming with Java, Mc Graw Hill, 2023, Seventh Edition.

MA1H02 **3-0-0 (3)**

Modeling and Simulation

Pre-Requisites: None

Course Outcomes:

CO-1	Analyze, design and begin to control rigorous mathematical models in continuous and discrete approaches.
CO-2	Use processes undertaken to arrive at a suitable mathematical model.
CO-3	Apply the fundamental analytical techniques and simulation methods used to develop insight into system behavior.
CO-4	Be familiar with a range (e.g., industrial, biological, and environmental) of study cases, associated conceptual models and their solutions using graphical, numerical and analytical approaches.
CO-5	Apply master simulation techniques using Simulink/Matlab software. Introduction to Mathematical

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	3
CO-2	2	3	3	–	2	1	1	–	–	–	–	–	1	1	3	3
CO-3	3	–	–	–	3	3	2	2	–	–	–	–	1	1	1	2
CO-4	2	3	3	–	2	1	1	–	–	–	–	–	1	1	3	3
CO-5	3	–	–	–	3	3	2	2	–	–	–	–	1	1	1	2

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

Syllabus:

Modeling Process: Concept; Objectives; Methods and tools Mathematics is the natural modeling language; Definition of mathematical models.

Modeling Continuous Systems: Modeling with Differential Equations: Population dynamic; Electrical Circuits; Mechanical Systems; Biological models (Lotka-Volterra systems, Predator-Prey systems).

Modeling with Partial Differential Equations: Linear Temperature Diffusion; One-dimensional Hydrodynamic model. Case Studies: Heat diffusion, Wave vibration, Laplace Equation.

Modeling Discrete Systems: Modeling with difference equations; Modeling with data; Discrete Velocity Models; Continuous Vs. Discrete Models.

Simulation: Block-Diagrams; State-Space Model; Transfer Functions, State-space Vs. transfer function. Stability and pole locations; Introduction to Matlab\Simulink (Starting Simulink, Basic Elements, Building a System, Running Simulations); Simulation of some models (case study models) and Analysis of Simulation results.

Learning Resources:

Text Books:

1. **Averill Law,** Simulation Modeling and Analysis with Expertfit Software, McGraw-Hill Science, 2007.
2. **M. M. Gibbons,** A Concrete Approach to Mathematical Modelling, Wiley-Interscience, 2007.

Reference Books:

1. **H. Neunzert, A. Siddiqui,** Topics in Industrial Mathematics, Kluwer Academic Publishers, 2000.
2. **D. Basmadjian,** Mathematical Modeling Physical systems: An Introduction; Oxford University Press, 2003.

MA1H03 **3-0-0 (3)**

Relational Database Management

Pre-Requisites: None

Course Outcomes:

CO-1	Understand functional components of the DBMS.
CO-2	Devise queries using Relational Algebra, Relational Calculus and SQL.
CO-3	Design database schema.
CO-4	Develop E-R model.
CO-5	Evaluate and optimize queries.

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	1	–	–	–	–	–	–	–	–	–	–
CO-2	2	2	2	2	2	1	–	–	–	–	–	–	–	–	–	–
CO-3	2	3	2	2	3	1	–	–	–	–	–	–	–	–	–	–
CO-4	2	2	1	1	1	2	–	–	–	–	–	–	–	–	–	–
CO-5	2	1	1	1	3	1	–	–	–	–	–	–	–	–	–	–

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, Schemas, Instances,

independence,

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;

Database Design: Mapping ER model to Relational form; Functional Dependency–Normalization process – 1NF, 2NF, 3NF and BCNF; Multivalued dependency and 4NF; Join dependency– PJNF

Query languages: Relational Algebra, Relational Calculus, Basics of SQL, DDL,DML,DCL, structure – creation, alteration, defining constraints – Primary key, foreign key, unique, not null, check, IN operator, Functions - aggregate functions, Built-in functions –numeric, date, string functions, set operations, sub-queries, correlated sub-queries, Use of group by, having, order by, join and its types, Exist, Any, All view and its types. transaction control commands – Commit, Rollback, Savepoint, triggers and Embedded SQL;

L/SQL Concepts PL/SQL Block, Stored Procedures, Functions and Packages (Except Cursor Management)

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;

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

Security and Authorization: Access control, direct access control and Mandatory access control, Role of DBA, Application development.

Learning Resources:

Text Books:

1. Elamsri, Navathe, Somayajulu and Gupta, Fundamentals of Database Systems, 6thEdition, Pearson Education, 2011.
2. Raghu Ramakrishnan, Johannes Gehrke, Database Management Systems, 3nd Edition, McGraw Hill, 2003.
3. Silberschatz, Korth and Sudharshan, Database System Concepts, 6rd Edition, McGrawHill, 2010.

Text Books:

1. Ivan Bayross, SQL, PL/SQL the Programming Language of Oracle, 4th Edition, BPB Publications

Online Resources

1. https://docs.oracle.com/en/database/index.html
2. https://docs.oracle.com/database/121/SQLRF/toc.html

MA1H04 **3-0-0 (3)**

Neural Networks

Pre-Requisites: None

Course Outcomes:

CO-1	Construct prediction models for statistical data
CO-2	Design Multi-Layer neural network to solve Supervised Learning problems
CO-3	Classify non-linear data like face recognition and disease prediction
CO-4	Apply Genetic Algorithm for optimization problems
CO-5	Design applications like games and agent-based controllers

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	3	3	2	3	3	1	–	–	–	–	–	–	–	–	–	–
CO-3	3	2	3	3	3	2	–	–	–	–	–	–	–	–	–	–
CO-4	3	2	3	2	2	1	–	–	–	–	–	–	–	–	–	–
CO-5	3	3	3	1	3	2	–	–	–	–	–	–	–	–	–	–

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to machine learning, issues related to machine learning: pre-processing, inductive bias, variance, feature extraction, and feature selection techniques. Different types of learning, training, and testing, hypothesis, and cost function.

Mathematics for machine learning: Regression techniques: linear, logistic, regularization, and generalization.

Classification techniques: DECISION TREES (DT)-construction of decision trees using different algorithms, Regression tree, tree pruning, rule extraction from trees, and multivariate trees. Ensemble learning: Bagging and boosting and different techniques of bagging and boosting. **Artificial neural networks (ANN):** different learning rules, single-layer perceptron, multi-layer neural nets, backpropagation algorithm, feed-forward networks, network training, radial basis function networks, recurrent neural networks. Bayesian learning: probabilistic reasoning: prior, likelihood, and posterior, belief networks: modeling independence, Markov equivalence in belief networks, hidden Markov models (HMM). Naïve Bayes classifier, learning with hidden variables, Expectation Maximisation (EM). - GENETIC ALGORITHMS – an illustrative example, Hypothesis space search, Genetic Programming, Models of Evolution and Learning. Instance-based learning: Nearest-Neighbour classification, condensed-neighbour classification. Unsupervised linear dimensionality reduction: principal component analysis(PCA), PCA vs singular value decomposition, working on high-dimensional data, latent-semantic analysis: information retrieval. Supervised linear dimensionality reduction: Fisher's linear discriminant. Kernel methods: dual representations, kernel construction, learning with hyperparameters, support vector machines (maximum margin classifier), linear and multiclass SVM.

Reinforcement learning - The Learning Task, Q Learning, Nondeterministic rewards and actions, Temporal difference learning, Generalizing from examples, and relationship to Dynamic Programming.

Learning Resources:

Textbooks:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2016.
2. Tom M. Mitchell, Machine Learning, McGraw Hill, 2017.

Reference Books:

1. Ethem Alpaydin, Introduction to machine learning, MIT Press, 2020.
2. Sebastian Raschka, Python Machine Learning, Packt Publishing,2017, Second Edition.

MA1H05 **3-0-0 (3)**

Statistical Learning

Pre-Requisites: None

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

CO-1	Understand functions of one random variable, functions of multiple random variables with all relevant parameters
CO-2	Utilize the knowledge of random variables, distributions in multivariate analysis
CO-3	Apply the concepts of regression in predictive models
CO-4	Understand the concept of dimension reduction and PCA
CO-5	Learn the concepts about KKN, K-means clustering and Naïve Baye's classifier

Syllabus:

Brief Introduction to Random Variables: Brief overview of random variables, known special probability distributions; Functions of one random variable – mean, variance, moments**.**

Multivariate Probability Distributions: Two random variables – bivariate distributions, joint distributions; functions of multiple random variables - Expectation, Scatter plots and spread, Variance and standard deviation, Covariance and correlation, Inequalities; Multiple continuous random variables; Averages of random variables, Jointly Gaussian random variables.

Regression, Classification: Linear Regression, logistic regression, Multiple linear regression, parameter estimation; Dimensionality reduction - Principal Component Analysis, linear discriminant analysis; Density estimation with Gaussian mixture models; classification with support vector machines – separating hyperplanes, primal and dual support vector machines, kernels.

Clustering: K-nearest Neighbours, K-means clustering, Naïve Baye's classifier**.**

Learning Resources:

Text Books:

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 2018, Seventh Edition
2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani and Jonathan An Introduction to Statistical Learning with Applications in Python, Taylor, Springer, 2023, First edition

Reference Books:

1. Norman Matloff, Probability and Statistics for Data Science: Math + R + Data, CRC Press, 2020, First edition
2. Daniel J. Denis, Univariate, Bivariate, and Multivariate Statistics using R, John Wiley & Sons, 2020, First Edition