CURRICULUM & SYLLABI
B.Tech.
COMPUTER SCIENCE AND ENGINEERING
(ARTIFICIAL INTELLIGENCE & DATA SCIENCE)

Effective from AY: 2024-25

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL
WARANGAL, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

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

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for 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
COMPUTER SCIENCE & ENGINEERING

VISION

Attaining global recognition in Computer Science & Engineering education, research and training to meet the growing needs of the industry and society

MISSION

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

Program: B.Tech. Computer Science and Engineering (Artificial Intelligence & Data Science)

Program Educational Objectives

PEO-1	Apply Data Science Principles blended with Artificial Intelligent techniques and Machine Learning Algorithms to model data driven intelligent systems.
PEO-2	Design, implement, test and maintain cognitive software systems based on requirement specifications.
PEO-3	Communicate effectively with team members, engage in applying technologies and lead teams in knowledge-based projects.
PEO-4	Assess the autonomous systems from the view point of quality, security, privacy, cost, utility, etiquette and ethics.
PEO-5	Engage in lifelong learning, research and development activities to impact the society with innovative intelligent solutions to the problems needing automation and high degree of scalability.

Program Articulation Matrix

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: B.Tech. Computer Science and Engineering (Artificial Intelligence & Data Science)

Program Outcomes

PO-1	**Engineering knowledge**: Apply the knowledge of mathematics, science, Engineering fundamentals, and Artificial Intelligence & Data Science to the solution of complex engineering problems.
PO-2	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO-3	**Design/Development of solutions:** Design solutions for complex engineering problems and design Artificial Intelligence system components or Data Science processes that meet the specified needs with appropriate consideration for the 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 Artificial Intelligence & Data Science based 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 the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1	Design algorithms for real world data-intensive problems and analyze their complexities.
PSO2	Design and develop interfaces for cohesive subsystems of Artificial Intelligent Systems.
PSO3	Learn from large data samples and generate plausible representations to build models for performing tasks related to engineering problems.
PSO4	Assess security, privacy, quality and cost parameters in developing AI based software systems.

CURRICULUM

B.Tech. Computer Science and Engineering (Artificial Intelligence & Data Science)

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	HS1161	English for Technical Communication	2-0-2	3
4	CS1101	Programming and Data Structures	3-0-0	3
5	BT1161	Biology for Engineers	2-0-0	2
6	CS1103	Programming and Data Structures Lab	0-1-2	2
7	IC1101	EAA–I (Games & Sports / Yoga & Wellness)	0-0-0	0
		Total Credits		**17**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MA1162	Integral and Vector Calculus. Laplace and Fourier Transforms	3-0-0	3
2	EE1161	Basic Electrical & Electronics Engineering	3-0-0	3
3	CS2102	Design Thinking	0-1-4	3
4	CS1104	Optimization Techniques	3-0-0	3
5	CS1106	Data Structures and Algorithms	3-0-2	4
6	CS1108	Web Programming Lab	0-1-2	2
7	CS2104	Discrete Mathematics	3-0-0	3
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	MA1264	Probability and Statistics	3-0-0	3
2	EC1263	Computer Organization and Architecture	3-0-2	4
3	CS2201	Theory of Automata and Compiler Design	4-0-0	4
4	CS2203	Python Programming	3-0-0	3
5	CS2205	Algorithm Design	3-0-0	3
6	CS2207	Python Programming Lab	0-1-2	2
7	CS2209	Statistical Tools Practice	0-1-2	2
			Total Credits	**21**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	MS1262	Business Essentials for Engineers	3-0-0	3
2	CS2202	Artificial Intelligence	3-0-2	4
3	CS2204	Machine Learning	3-0-2	4
4	CS2206	Database Systems	3-0-0	3
5	CS2208	Operating Systems Design	3-0-0	3
6	CS2210	Database Systems Lab	0-1-2	2
7	CS2212	Operating Systems Lab	0-1-2	2
			Total Credits	**21**

5th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CS2301	Software Engineering	3-0-2	4
2	CS2303	Data Science Fundamentals	4-0-0	4
3	CS2305	Computer Networks	3-0-0	3
4	CS2307	Data Visualization Techniques and Design	3-0-0	3
5	CS23XX	Professional Elective - I	3-0-0	3
6	CS2381	Fractal Course I	1-0-0	0.5
7	CS2309	Computer Networks Lab	0-1-2	2
8	CS2311	Data Science Lab	0-1-2	2
			Total Credits	**21.5**

6th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CS2302	Deep Learning	4-0-0	4
2	CS2304	Natural Language Processing	3-0-0	3
3	CS23XX	Professional Elective - II	3-0-0	3
4	CS23XX	Professional Elective - III	3-0-0	3
5	CS2306	Product Development	0-1-4	3
6	CS2382	Fractal Course II	1-0-0	0.5
7	CS2308	Deep Learning Lab	0-1-2	2
8	CS2310	Natural Language Processing Lab	0-1-2	2
			Total Credits	**20.5**

7th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CS2401	High Performance Computing	3-0-0	3
2	CS24XX	Professional Elective-IV	3-0-0	3
3	CS24XX	Professional Elective-V	3-0-0	3
4		Open Elective-1	2-0-0	2
5	CS2403	High Performance Computing Lab	0-1-2	2
6	CS2489	Seminar and Technical Writing	0-0-0	2
7	CS2495	Minor Project	0-0-0	2
8	CS2491	Short Term Industrial/EPICS/Research Experience	0-0-0	2
			Total Credits	**19**

8th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CS24XX	Professional Elective - VI	3-0-0	3
2	CS24XX	Professional Elective - VII	3-0-0	3
3	CS24XX	Professional Elective - VIII	3-0-0	3
4	CS2498	Major Project	0-0-0	6
			Total Credits	**15**

Professional Electives:

Professional Elective-I for 5th Semester		
S.No.	**Code**	**Course Title**
1	CS2321	Business Intelligence
2	CS2323	Data Mining Algorithms
3	CS2325	Information Coding Theory
4	CS2327	Statistical Learning

Professional Elective-II, III for 6th Semester		
S.No.	**Code**	**Course Title**
1	CS2322	Advanced Databases
2	CS2324	Big Data Analytics
3	CS2326	Database Security
4	CS2328	Formal Verification of Machine Learning Models
5	CS2330	Information Retrieval
6	CS2332	Soft Computing
7	CS2334	Speech Technology
8	CS2336	Time Series and Text Mining

Professional Elective-IV, V for 7th Semester		
S.No.	**Code**	**Course Title**
1	CS2421	Computer Vision and Image Processing
2	CS2423	Intruder Detection Systems
3	CS2425	IoT Data Processing
4	CS2427	Medical Image Processing
5	CS2429	Quantum Computing
6	CS2431	Recommendation Systems
7	CS2433	Sequential Decision Systems
8	CS2435	Social Media Analytics

Professional Elective-VI, VII, VIII for 8th Semester		
S.No.	**Code**	**Course Title**
1	CS2432	AI in Robotics
2	CS2434	Cloud Data Management
3	CS2436	Computational Neuro Science
4	CS2438	Cyber Physical Systems
5	CS2440	Federated Machine Learning
6	CS2442	Game Theory and Strategy
7	CS2444	Human Computer Interaction
8	CS2446	Large Language Models
9	CS2448	Reinforcement Learning
10	CS2450	Security and Privacy for Online Social Media
11	CS2452	Semantic Web
12	CS2454	Social Networks
13	CS2456	Video Analytics
14	CS2458	Virtual Reality and Augmented Reality

Basic Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	MA1161	Linear Algebra, Calculus and Ordinary Differential Equations	3-0-0	3
2	PH1161	Engineering Physics	3-0-2	4
3	BT1161	Biology for Engineers	2-0-0	2
4	MA1162	Integral and Vector Calculus, Laplace and Fourier Transforms	3-0-0	3
5	MA1264	Probability and Statistics	3-0-0	3

Engineering Science Courses

S.No.	Code	Course Title	L-T-P	Credits
1	CS1101	Programming and Data Structures	3-0-0	3
2	CS2102	Design Thinking	0-1-4	3
3	CS1103	Programming and Data Structures Lab	0-1-2	2
4	CS1104	Optimization Techniques	3-0-0	3
5	CS1106	Data Structures and Algorithms	3-0-2	4
6	EE1161	Basic Electrical & Electronics Engineering	3-0-0	3
7	CS2209	Statistical Tools Practice	0-1-2	2
8	EC1263	Computer Organization and Architecture	3-0-2	4
9	CS2306	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	MS1261	Business Essentials for Engineers	3-0-0	3

The Overall Credit Structure

Course Category	Credits
Basic Science	15
Engineering Science	27
Humanities and Social Sciences	6
Program Core	82
Professional Elective	24
Open Elective	2
Total Graded Credit Requirement	156

Honors Degree: Computer Science and Engineering (Artificial Intelligence & Data Science):

Code	Course Title	L-T-P	Credits	semester
CS2H01	Multi Agent Systems	3-0-0	3	V
CS2H02	Responsible and Explainable Artificial Intelligence	3-0-0	3	VI
CS2H04	Advanced Topics in Data Mining	3-0-0	3	VI
CS2H05	Deep Reinforcement Learning	3-0-0	3	VII
CS2H07	Generative AI	3-0-0	3	VII
CS2H08	Streaming Data Analytics	3-0-0	3	VIII
CS2H10	Web Intelligence & Web Analytics	3-0-0	3	VIII

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

SYLLABI

B.Tech.

Computer Science and Engineering

(Artificial Intelligence & Data Science)

1st Semester

MA1161 **3-0-0 (3)**

Linear Algebra, Calculus and Ordinary Differential Equations

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

Linear Algebra: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

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

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

Learning Resources:

Text Books:

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, Eleventh Edition.
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

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

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

Engineering Physics

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

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

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

Nanomaterials: Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-

down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials.

Ultrasonics: Production, detection, and applications of ultrasonics

List of Experiments:

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

Learning Resources:

Text Books:

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

Reference Books:

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

Online Resources:

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

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

English for Technical Communication

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

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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

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

Technical Writing: Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy, and Wordiness, - Kinds of Graphics and Their Messages, - Suitability for Placement in Graphic Representation, - Introduction to Basic Concepts in Research, - Abstract, Keywords, Methodology, Hypothesis, Plagiarism, Critical Reading, - Abstract Writing, - How to Read Scientific Articles, - Basics of Writing a Research Project Proposal, - Preparation and Presentation of Project Reports.

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

Language laboratory:

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

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

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

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

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

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

Learning Resources:

Text Books:

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

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

Programming and Data Structures

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design algorithms for solving simple mathematical problems including computing, searching and sorting.
CO-2	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems.
CO-3	Explore the internals of computing systems to suitably develop efficient algorithms.
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	Understand the concept of abstract data types and apply them in real-world 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	3	1	1	1	2	1	-	-	-	-	-	3	3	3	3	3
CO-2	2	1	2	1	2	3	-	-	-	-	-	3	3	2	2	2
CO-3	1	2	2	2	2	1	-	-	-	-	-	3	3	2	2	1
CO-4	2	2	2	2	2	2	-	-	-	-	-	2	3	2	1	2
CO-5	2	2	3	1	2	2	-	-	-	-	-	2	3	2	2	2
CO-6	2	2	3	2	2	2	-	-	-	-	-	2	3	2	2	2

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

Syllabus:

Fundamentals of Computers - Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, 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, conditional and branch statements: If-else, Switch-case constructs, iteration statements: while, do-while, for, Arrays – Single and Multi-Dimensional Arrays, strings. Bit-wise operations.

Functions and Recursion – 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.

Structures and Classes - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

Pointers and Files - Introduction to pointers and dynamic allocation, String processing, File operations-create, read and write.

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

Data structures - 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. Cay Horstmann, Timothy Budd, Big C++, Wiley, 2009, Second Edition.

Reference Books:

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

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

Biology for Engineers

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

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

Learning Resources:

Text Books:

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

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

Programming and Data Structures Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Design and test programs to solve mathematical and scientific problems.
CO-2	Develop and test programs using control structures.
CO-3	Implement modular programs using functions.
CO-4	Develop programs using classes.
CO-5	Develop ADT for stack and queue 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	3	2	2	1	2	1	-	-	-	-	-	-	3	3	3	3
CO-2	1	1	2	1	2	2	-	-	-	-	-	-	3	3	2	2
CO-3	1	2	3	2	2	1	-	-	-	-	-	-	3	3	2	2
CO-4	2	2	2	2	2	3	-	-	-	-	-	-	2	3	2	1
CO-5	2	2	2	2	2	3	-	-	-	-	-	-	2	3	2	1

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, 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 of stack and queue.

Learning Resources:

Text Books:

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

Reference Books:

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

2nd Semester

MA1162 **3-0-0 (3)**

Integral and Vector Calculus, Laplace and Fourier Transforms

Pre-requisites: MA1161

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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

Laplace Transforms: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem;. **Fourier Series:** Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions.

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

Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, Thirteenth Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

EE1161 **3-0-0 (3)**

Basic Electrical & Electronics Engineering

Pre-Requisites: **None**

Course Outcomes:

CO-1	Able to Analyze DC & AC circuits and determine power & power factor.
CO-2	Able to Understand the operation and characteristics of various electrical machines.
CO-3	Understand the operation of basic electronic circuits and characteristics of semiconductor devices.
CO-4	Able to select appropriate meters/transducers for measurement of various electrical /non-electrical quantities.

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.

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

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

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

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

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

CS2102 **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	-	3	-	1	-	-	-	-	-	2	-	1	3	1	1	1
CO-2	-	2	-	2	-	-	-	-	-		-	-	1	-	-	1
CO-3	-	2	-	1	-	-	-	-	-	2	-	-	-	2	1	
CO-4	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	2
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

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. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st Edition.
2. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Tim Brown.

Reference Books:

1. George E. Dieter, Linda C. Schmidt Engineering Design 5th Edition, 2019.
2. Ulrich, K., Eppinger, S. and Yang, M.,. Product Design and development, 7th Edition, 2020.

CS1104 **3-0-0 (3)**

Optimization Techniques

Pre-Requisites: **CS1101, CS1106**

Course Outcomes:

CO-1	Prepare and solve linear programming model.
CO-2	Model transportation and flow through networks and compute optimal parameters.
CO-3	Optimize inventory levels.
CO-4	Solve real life problems using Meta-heuristic techniques.
CO-5	Generate random numbers and random variates.
CO-6	Verify and validate simulation models.

Course Articulation Matrix:

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

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

Syllabus:

Modelling with linear programming – The Simplex method, Sensitivity Analysis, Integer linear programming: Branch and Bound technique – Transportation Model and its variants, Network Model: CPM and PERT - Deterministic and non-deterministic inventory models.

Heuristic and Meta Heuristic Programming: Simulated Annealing, Genetic Algorithm, Particle warm Optimization algorithm and Teaching learning-based optimization algorithm - Non-Linear Programming algorithms.

Introduction to Quadratic Programming: Constrained Optimization Problem Solving, Convex Optimization Methods.

Simulation Modelling: Random number generation, Random variate generation – Verification and Validation of simulation models, Simulation of Computer Systems and Computer Networks.

Learning Resources:

Text Books:

1. Hamdy A Taha – “Operations Research-An Introduction”, 9th Edition, Pearson, 2017 (Chapters 1-8, 12, 14, 17)
2. Jerry Banks, Hon S Carson, Barry L Nelson, David M Nicol, “Discrete Event Simulation", 5th Edition, Pearson, 2010 (Chapters 8 – 12, 14, 15).

CS1106 **3-0-2 (4)**

Data Structures and Algorithms

Pre-Requisites: **CS1101**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

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

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

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

Learning Resources:

Text Books:

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

Reference Books:

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

CS1108 **0-1-2 (2)**

Web Programming Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand, analyze and build dynamic and interactive web sites.
CO-2	Understand current and evolving Web languages for integrating media and user interaction in both front end and back end elements of a Web site.
CO-3	Analysis and reporting of web data using web analytics.
CO-4	Applying different testing and debugging techniques and analyzing the web site effectiveness.

Course Articulation Matrix:

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

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

Syllabus:

Introduction to XHTML: Editing XHTML, First XHTML Example, W3C XHTML Validation Service, Headers, Linking, Images, Special Characters and More Line Breaks, Unordered Lists, Nested and Ordered Lists, Internet and World Wide Web Resources.

Dynamic HTML: Object Model and Collections- Introduction, Object Referencing, Collections all and children, Dynamic Styles, Dynamic Positioning, Using the frames Collection, navigator Object, Summary of the DHTML Object Model; Event Model- vent onclick, Event onload, Error Handling with onerror, Tracking the Mouse with Event onmousemove, Rollovers with onmouseover and onmouseout; Form Processing- Form Processing with onfocus and onblur, More Form Processing with onsubmit and onreset, Event Bubbling, More DHTML Events; Filters and transitions; Data binding with tabular data control, Structured graphics and active X control.

JavaScript: Functions; Program Modules in JavaScript, Programmer Defined Functions, Function Definitions, Random-Number Generation, Duration of Identifiers, Scope Rules, JavaScript Global Functions, Recursion, JavaScript arrays, JavaScript objects.

Learning Resources:

Text Books:

1. Deitel, Deitel and Nieto, "Internet and Worldwide Web - How to Program", 5th Edition, PHI, 2011.
2. Bai and Ekedhi, "The Web Warrior Guide to Web Programming", 3rd Edition, Thomson, 2008.

CS2104 **3-0-0 (3)**

Discrete Mathematics

Pre-Requisites: None

Course Outcomes:

CO-1	Apply formal methods of proof to solve discrete problems.
CO-2	Apply Propositional logic and First order logic to solve problems.
CO-3	Formulate and solve graph problems.
CO-4	Formulate and solve recurrence relations.
CO-5	Apply techniques for counting discrete event occurrences.

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Mathematical Logic and Normal Forms: Statements and Notation, Connectives, Functionally Complete Set of Connectives, Methods of Proof of an Implication, Inference Theory of Propositional Logic, Normal Forms, Limitations of Propositional Logic, Quantified Propositions, Predicate Logic and other Methods of Proof, Rules of Inference for Quantified Propositions.

Graph Theory: Basic Definitions, Representation of Graphs, Connected Components, Connectivity of Graphs, Block Graphs, Trees, Graph Isomorphism, Planar Graphs, Euler's Formula, Eulerian Graphs, Hamiltonian Graphs, Chromatic Number of a Graph, Brook`s Theorem, Planar Graph Coloring, Applications of Graph Coloring, Domination Number of a Graph, Bounds on Domination Number, Applications of Domination.

Recurrence Relations: Solving Recurrence Relations by Substitution Method, The Method of Characteristic Roots, Solutions of Homogeneous and Inhomogeneous Recurrence Relations using Characteristic Roots Method, Closed Form Formula for nth Fibonacci Number, Counting Minimum Number of Nodes in an AVL Tree of Given Height, Generating Functions of Sequences, Solving Recurrence Relations using Generating Functions, Counting Number of Binary Search Trees using Generating Functions.

Elementary Combinatorics: Basics of Counting, Combinations and Permutations, Enumeration of Combinations and Permutations, Enumerating Combinations and Permutations with Repetitions, Enumerating Permutations with Constrained Repetitions, Binomial Coefficients, The Binomial and Multinomial Theorems, The Principle of Inclusion-Exclusion, Stirling Numbers of the Second Kind.

Learning Resources:

Text Books:

1. Kenneth H. Rosen, "Discrete Mathematics and Its Applications with Combinatorics and Graph Theory", McGraw Hill Education, 2011, 7th Edition.
2. Joe L. Mott, Abraham Kandel, Theodore P. Baker, "Discrete Mathematics for Computer Scientists and Mathematicians", PHI, 2001, 2nd Edition.

Reference Books:

1. Gary Chartrand and Ping Zhang, Introduction to Graph Theory, McGraw-Hill Higher Education, 2006, 1st Edition.
2. Tremblay J. P. and Manohar R., "Discrete Mathematical Structures", McGraw Hill Education, 2017, 1st Edition.

Other Suggested Readings:

1. NPTEL Course on Discrete Mathematical Structures by Prof. Kamala Krithivasan, IIT Madras.

3rd Semester

MA1264 **3-0-0 (3)**

Probability and Statistics

Pre-requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

Review of basics of Probability and descriptive statistics.

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

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

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

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

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

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

Learning Resources:

Text Books:

1. R. A. Johnson, Miller and Freund's "Probability and Statistics for Engineers", Pearson Publishers, 9th Edition, 2017.
2. John E. Freund, Benjamin M. Perles, "Modern Elementary Statistics", 12th Edition, Pearson, 2013.
3. Hamdy A. Taha, "Operations Research: An Introduction", Pearson, 2017, Tenth Edition.
4. S.C.Gupta and V.K.Kapoor, "Fundamentals of Mathematical Statistics", 12th Edition, S.Chand & Co, 2020.
5. Kantiswarup, P.K.Gupta and Manmohan Singh, "Operations Research", Sultan Chand & Sons, 2014.

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.

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

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

Learning Resources:

Text Books:

1. Carl Hamacher, "Computer Organization", 5th Edition, McGraw Hill Publishers, 2002.
2. Wiiliam Stallings, "Computer Organization and Architecture Designing for Performance", 8th Edition, Pearson Education, 2010.

Reference Books:

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

CS2201 **4-0-0 (4)**

Theory of Automata and Compiler Design

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

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

Syllabus:

Automata: The Methods and the Madness: Why study automata theory? Introduction to formal proof; Additional forms of proof; Inductive proofs; The central concepts of automata theory.

Finite Automata: An informal picture of finite automata; Deterministic finite automata; Nondeterministic finite automata; An application: text search; Finite automata with epsilon-transitions.

Regular Expressions and Languages: Regular expressions; Finite automata and regular expressions; Applications of regular expressions; Algebraic laws for regular expressions.

Properties of Regular Languages: Proving languages not to be regular; Closure properties of regular languages; Decision properties of regular languages; Equivalence and minimization of automata.

Context-Free Grammars and Languages: Context-free grammars; Parse trees; Applications of context-free grammars; Ambiguity in grammars and languages.

Pushdown Automata: Definition of pushdown automata; The languages of a PDA; Equivalence of PDA's and CFG's; Deterministic pushdown automata.

Properties of Context-Free Languages: Normal forms for context-free grammars; The pumping lemma for context-free languages; Closure properties of context-free languages; Decision properties of CFL's.

Introduction to Turing Machines: Problems that computers cannot solve; The Turing machine; Programming techniques for Turing machines; Extensions to the basic Turing machine; Restricted Turing machine; Turing machines and computers.

Undecidability: A language that is not recursively enumerable; An undecidable problem that is RE; Undecidable problems about Turing machines; Post's correspondence problem; Other undecidable problems.

Learning Resources:

Text Books:

1. John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education, 2006, Third Edition.

Reference Books:

1. Peter Linz, An Introduction to Formal Languages and Automata, Jones and Bartlett Learning, 2013, Sixth Edition.
2. K. L. P. Mishra and N. Chandrasekaran, Theory of Computer Science: Automata, Languages and Computation, PHI, 2006, Third Edition.

Other Suggested Readings:

1. NPTEL Course on Theory of Computation by Prof. Raghunath Tiwari, IIT Kanpur.

CS2203 **3-0-0 (3)**

Python Programming

Pre-requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Python Programming Language, Features of Python Programming Language , Flavours of Python Programming Language , Installation of Python Programming Language , Execution of First Python Program, Data Types , Fundamental Data Types , Collection Data Types – Lists, Tuples, Sets, Frozen sets, Dictionaries –, Variables , Operators, Control Statements , Conditional Statements, Looping Statements , Logical Programs, String Handling, File handling, Object Oriented Programming in Python, Exception Handling in Python, Different modules and packages for scientific computing in python (Numpy, Pandas, Matplotlib, Scipy, Sympy, etc.) , Database access, Regular Expressions.

Learning Resources:

Text Books:

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

References:

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

CS2205 **3-0-0 (3)**

Algorithm Design

Pre-Requisites: **CS1101, CS1106**

Course Outcomes:

CO-1	Analyze time and space complexities of algorithms.
CO-2	Identify algorithm design methodology to solve problems.
CO-3	Distinguish between P and NP classes of problems.
CO-4	Design and analyze approximation algorithms for NP-hard problems.

Course Articulation Matrix:

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

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

Syllabus:

Asymptotic Analysis: Asymptotic Notations, Worst-case running time of algorithms.
Divide and Conquer: Master Theorem, Maximum Element in an Unimodal Array, Maximum Subarray Sum Problem, Expected Running Time of Randomized Quick Sort, Strassen's Matrix Multiplication Algorithm, Karatsuba's Large Integer Multiplication and Selection in Worst Case Linear Time.

Dynamic Programming: Elements of Dynamic Programming, Matrix Chain Multiplication Problem, Optimal Binary Search Tree, Rod-Cutting Problem, 0-1 Knapsack Problem, Travelling Salesman Problem, All-Pairs Shortest Paths Problem and Optimal Vertex Cover of a Tree.

Greedy Method: Activity Selection Problem, Fractional Knapsack Problem, Correctness and Running Time Analysis of Prim's and Kruskal's Algorithms for Finding Minimum Spanning Tree and Dijkstra`s Algorihm for Single Source Shortest Path Problem.

Complexity Classes: P, NP, NP-hard, NP-complete, Example NP-complete Problems – Clique, Independent Set and Vertex Cover, Methods to cope-up with NP-hardness of a Problem.

Approximation Algorithms: Approximation Ratio, Absolute Approximation Algorithm for Planar Graph Coloring and 2-approximation Algorithm for Vertex Cover Problem.

Learning Resources:

Text Books:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, PHI, 2009, Third Edition.
2. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, Fundamentals of Computer Algorithms, Universities Press, 2011, Second Edition.

Reference Books:

1. Steven S Skiena, The Algorithm Design Manual, Springer, 2008, Second Edition.
2. Michael R. Garey and David S. Johnson, Computers and Intractability: A Guide the theory of NP-Completeness, W.H. Freeman & Co., 1979.

Other Suggested Readings:

1. NPTEL Course on Design and Analysis of Algorithms by Prof. Abhiram G.Ranade et al.
2. https://www.algorist.com/

CS2207 **0-1-2 (2)**

Python Programming Lab

Pre-requisites: **None**

Course Outcomes:

CO-1	Proficiency in Python syntax and constructs demonstrated through algorithmic implementations.
CO-2	Application of object-oriented principles in designing and implementing Python solutions for real-world challenges.
CO-3	Effective utilization of Python libraries for data manipulation, visualization, and task automation across domains.
CO-4	Collaborative project development showcasing creativity and problem-solving process in Python programming.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Accessing databases using python, Experiments on APIs, web development using python programming. Experiments on libraries-standard (math, random), external (NumPy, Pandas, Matplotlib)

Learning Resources:

Text Books:

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

References:

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

CS2209 **0-1-2 (2)**

Statistical Tools Practice

Pre-Requisites: **MA1161, MA1162**

Course Outcomes:

CO-1	Apply statistical methods to data for inferences.
CO-2	Access online resources for R and import new function packages into the R workspace.
CO-3	Import, review, manipulate and summarize data-sets in R.
CO-4	Perform descriptive analytics over large scale data and apply appropriate statistical tests using R.
CO-5	Explore data-sets to create testable hypotheses and identify appropriate statistical tests.

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

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

Syllabus:

Introduction to Data Science and data visualization: Introduction, How to run R, R Sessions and functions, Basic Math, Variables, Data Types, Vectors, Conclusion, Advanced Data Structures, Data Frames, Lists, Matrices, Arrays, Classes**.**

R Programming: Structures, Control Statements, Loops, - Looping Over Nonvictory Sets,- If-Else, Arithmetic and Boolean Operators and values, Default Values for Argument, Return Values, Deciding Whether to explicitly call return- Returning Complex Objects, Functions are Objective, No Pointers in R, Recursion, A Quicksort Implementation-Extended Extended Example: A Binary Search Tree.

Doing Math and Simulation in R: Math Function, Extended Example Calculating Probability- Cumulative Sums and Products-Minima and Maxima- Calculus, Functions Fir Statistical Distribution, Sorting, Linear Algebra Operation on Vectors and Matrices, Extended Example: Vector cross Product- Extended Example: Finding Stationary Distribution of Markov Chains, Set Operation, Input /output, Accessing the Keyboard and Monitor, Reading and writer Files.

Graphics: Creating Graphs, The Workhorse of R Base Graphics, the plot () Function –Customizing Graphs, Saving Graphs to Files.

Probability Distributions: Normal Distribution- Binomial Distribution- Poisson Distributions Other Distribution, Basic Statistics, Correlation and Covariance, T-Tests,-ANOVA.

Linear Models: Simple Linear Regression, -Multiple Regression Generalized Linear Models, Logistic Regression, - Poisson Regression- other Generalized Linear Models-Survival Analysis, Nonlinear Models, Splines- Decision- Random Forests.

Learning Resources:

Text Books:

1. Norman Matloff, "*The Art of R Programmi*ng, No Starch Press, 2011.
2. Lander, "*R for Everyone*", Pearson.

Reference Books:

1. Paul Teetor, "*R Cookbook*", Oreilly
2. Rob Kabacoff, "*R in Action*", Manning

4th Semester

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/

CS2202 **3-0-2 (4)**

Artificial Intelligence

Pre-Requisites: **None**

Course Outcomes:

CO-1	Learn various agent models.
CO-2	Learn and implement various searching techniques on live examples.
CO-3	Create and design knowledge-based agents.
CO-4	Create and design agents to work in uncertain environments.
CO-5	Perform statistical learning on 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	–	–	2	–	–	–	3	3	3	1
CO-2	3	3	3	3	3	3	–	–	2	–	–	3	3	3	3	3
CO-3	3	3	3	3	3	3	–	–	2	–	–	3	3	3	3	3
CO-4	3	3	3	3	3	3	–	–	2	–	–	3	3	3	3	3
CO-5	3	3	3	3	3	3	–	–	2	–	–	3	3	3	3	3

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

Syllabus:

INTRODUCTION – Agents and Objects – Evaluation of Agents – Agent Design Philosophies - Multiagent System – Mobile Agents – Agent Communication – Knowledge query and Manipulation Language – Case Study. What is AI? , The Foundations of Artificial Intelligence; - INTELLIGENT AGENTS – Agents and Environments, Good Behavior: The Concept of Rationality, The Nature of Environments, The Structure of Agents; - SOLVING PROBLEMS BY SEARCH – Problem-Solving Agents, Formulating problems, Searching for Solutions, Uninformed Search Strategies, Breadth-first search, Depth-first search, Searching with Partial Information, Informed (Heuristic) Search Strategies, Greedy best-first search, A* Search: Minimizing the total estimated solution cost, Heuristic Functions, Local Search Algorithms and Optimization Problems, Online Search Agents and Unknown Environments; –ADVERSARIAL SEARCH – Games, The minimax algorithm, Optimal decisions in multiplayer games, Alpha-Beta Pruning, Evaluation functions, Cutting off search, Games that Include an Element of Chance; - LOGICAL AGENTS – Knowledge-Based agents, The Wumpus World, Logic, Propositional Logic: A Very Simple Logic, Reasoning Patterns in Propositional Logic, Resolution, Forward and Backward chaining; - FIRST ORDER LOGIC – Syntax and Semantics of First-Order Logic, Using First-Order Logic , Knowledge Engineering in First-Order Logic; - INFERENCE IN FIRST ORDER LOGIC – Propositional vs. First-Order Inference, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution ; - UNCERTAINTY – Acting under Uncertainty, Basic Probability Notation, The Axioms of Probability, Inference Using Full Joint Distributions, Independence, Bayes' Rule and its Use, The Wumpus World Revisited; - PROBABILISTIC REASONING – Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks; STATISTICAL LEARNING METHODS – Statistical Learning, Learning with Complete Data, Learning with Hidden Variables: EM Algorithm.

Learning Resources:

Text Books:

1. Stuart Russell and Peter Norvig, Artificial Intelligence, A Modern Approach, Pearson Publishers, 2020, 4th Edition.
2. Nils J Nilsson, "Artificial Intelligence: A New Synthesis", Morgan Kaufmann Publications, 2000.

Reference Books:

1. Kevin Knight, Elaine Rich and Shivshankar B. Nair, Artificial Intelligence, McGraw Hill, 2017, 3rd Edition.

CS2204 **3-0-2 (4)**

Machine Learning

Pre-Requisites: **CS1106**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

.

Learning Resources:

Text Books:

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

Reference Books:

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

CS2206 **3-0-0 (3)**

Database Systems

Pre-Requisites: **CS1106**

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.
CO-6	Analyze transaction processing, concurrency control and recovery 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	1	1	–	–	–	–	–	–	–	–	–	–	–	–	1	1
CO-2	2	1	–	–	2	1	–	1	–	2	2	1	–	1	–	–
CO-3	1	2	3	2	2	1	2	1	–	2	2	–	1	2	2	2
CO-4	1	3	3	2	2	1	2	1	–	2	2	–	1	2	2	2
CO-5	2	–	–	1	–	–	1	–	–	1	–	–	1	2	–	–
CO-6	–	1	2	1	1	–	1	1	–	1	2	–	–	2	–	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

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

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

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

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

Query Processing: Overview of Query Evaluation, operator evaluation; Algorithms for relational operations– Selection operation, General selection condition, Projection operation, Join operation, set operation and aggregate operation, Evaluation of relational operations; Query optimization: Alternative plans, functions of query optimizer, translating SQL queries into relational algebra, estimating the cost of a plan, relational algebra equivalences, and other approaches to query optimization.

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

and Advanced Recovery Techniques.

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

CS2208 **3-0-0 (3)**

Operating Systems Design

Pre-Requisites: **CS1106, EC1263**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

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

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

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

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

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

I/O Systems: Hardware, Application I/O Interface, Kernel I/O Subsystem, Transforming I/O to Hardware Operations, STREAMS, Performance, Disk Structure, Disk Scheduling, Disk Management, Swap-Space Management, RAID Structure, Disk Attachment, Stable-Storage Implementation, Tertiary-Storage Structure.

.**Learning Resources:**

Text Books:

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

CS2210 **0-1-2 (2)**

Database Systems Lab

Pre-Requisites: **CS1106**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

Learning Resources:

Text Books:

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

CS2212 **0-1-2 (2)**

Operating Systems Lab

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

Learning Resources:

Text Books:

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

5th Semester

CS2301 **3-0-2 (4)**

Software Engineering

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

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

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

Fault, and Failure, Test Case, Test Suite, and Test Harness, Psychology of Testing , Levels of Testing.

Testing Process - Test Plan, Test Case Design, Test Case Execution; Black-Box Testing – Equivalence Class Partitioning, Boundary Value Analysis, Pairwise Testing, Special Cases, State-Based Testing; White-Box Testing - Control Flow-Based Criteria, Test Case Generation and Tool Support; Metrics -Coverage Analysis, Reliability, Defect Removal Efficiency.

Learning Resources:

Text Books:

1. Pankaj Jalote, "Software Engineering Precise Approach" , Wiley Publishers, 2012.
2. Rajib Mall, Fundamentals of Software Engineering, PHI, 5th Edition , 2018.

Reference Books:

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

CS2303 **4-0-0 (4)**

Data Science Fundamentals

Pre-requisites: **CS2203, MA1264**

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

CO-1	Apply statistical methods to data for inferences.
CO-2	Analyze data using prediction methods.
CO-3	Understanding and Applying Data Wrangling approaches.
CO-4	Perform descriptive analytics and data visualization over massive 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	2	1	1	2	2	–	1	–	–	1	–	–	2	1	2	2
CO-2	2	1	2	2	2	–	1	–	–	1	–	–	2	2	3	2
CO-3	2	1	1	2	2	–	1	–	–	1	–	–	2	2	3	3
CO-4	2	2	2	2	2	1	2	–	–	1	1	–	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to data science, data science process, roles, tools, and technologies, data collection, data wrangling, focusing on techniques for data collection, cleaning, pre-processing, and transformation. Overview of Random variables and probability distributions. Statistical learning: Assessing model accuracy, Bias-Variance Trade-Off, Descriptive Statistics, Dependent and Independent events; Linear Regression: Simple and multiple linear regressions, regularization, Lasso, Ridge, and Elastic-Net Regression. Comparison of Linear regression with K-nearest neighbours. Logistic Regression, LDA, QDA. PCA and SVD. Hypothesis Testing, Student's t-test, paired t and U test, correlation and covariance, tests for association; association rules and correlations; hypothesis testing, correlation and causation, ANOVA, and statistical significance. Exploratory data analysis (EDA), descriptive statistics, data visualization techniques, and identifying patterns and trends, Histograms and frequency polygons, Box-plots, Quartiles, Scatter Plots, Heat Maps. Matrix visualization, Scientific Design Choices in Data Visualization, Higher-dimensional Displays and Special Structures, Visual data mining. Data Wrangling: Data Acquisition, Data Formats, Imputation, split-apply-combine paradigm. Descriptive Analytics: Data Warehousing and OLAP, Data Summarization, Data de- duplication, Data Visualization using CUBEs. Understanding Big Data, Hadoop, Spark basics, MapReduce, NoSQL databases, and applications. Implementation of the topics discussed above and applying learned techniques and tools to real-world problems.

Learning Resources:

Text Books:

1. Gareth James Daniela Witten Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Applications in R.
2. Mark Gardener, Beginning R The Statistical Programming Language, Wiley.
3. Han , Kamber, and J Pei, Data Mining Concepts and Techniques.

Reference Books:

1. C Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. Chun-houh Chen, Wolfgang Hardle, Antony Unwin, Handbook of Data Visualization, Springer, 2008.

Other Suggested Readings:

1. https://www.kdnuggets.com/topic/data-science
2. https://www.kdnuggets.com/topic/data-visualization

CS2305 **3-0-0 (3)**

Computer Networks

Pre-Requisites: **CS2208 Operating Systems Design**

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 Models.

Datalink Layer-Ethernet, Token ring, wireless LANs-Issues with data link Protocols-Encoding framing and 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 application protocols.

.Learning Resources:

Text Books:

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

CS2307 **3-0-0 (3)**

Data Visualization Techniques and Design

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply graphical methods to data for inferences.
CO-2	Analyze data using Graphical and Computational methods.
CO-3	Understand advanced visualization techniques.
CO-4	Perform data visualization over massive 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	2	1	1	2	–	1	–	1	1	–	1	–	3	2	–	1
CO-2	2	1	3	2	1	1	–	–	–	1	1	–	3	1	1	2
CO-3	1	2	2	3	1	2	–	2	–	1	–	2	2	1	1	1
CO-4	1	2	2	3	–	2	–	–	1	–	–	–	3	2	2	–

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

Syllabus:

Data Visualization and Graphical Analysis: Visualized exploratory data Analysis, Histograms and frequency polygons, Box-plots, Quartiles, Scatter Plots, Heat Maps. Matrix visualization, Scientific Design Choices in Data Visualization, Higher-dimensional Displays and Special Structures, t-SNE Plots, Visual data mining. Data Visualization using OLAP CUBEs. Visualization Tools.

Learning Resources:

Text Books:

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

Reference Books:

1. Claus O. Wilke, Fundamentals of Data Visualization," published by O'Reilly Media, Inc. (eBook)

Other Suggested Readings:

1. https://www.kdnuggets.com/topic/data-science
2. https://www.kdnuggets.com/topic/data-visualization

CS2381 **1-0-0 (0.5)**

Fractal Course I

Pre-Requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

a. Structure: Lectures delivered by an expert from the Computer Science and Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

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

CS2309 **0-1-2 (2)**

Computer Networks Lab

Pre-Requisites: **None**

Course Outcomes:

CO-1	Develop programs for client-server applications.
CO-2	Perform packet sniffing and analyze packets in network traffic.
CO-3	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	3	2	3	-	2	-	2	-	-	-	-	2	2	2	-	-
CO-2	2	3	2	2	1	1	-	2	-	-	-	1	1	2	-	2
CO-3	1	1	1	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, Second Edition, 2013.

CS2311 **0-1-2 (2)**

Data Science Lab

Pre-requisites:

Course Outcomes:

CO1	Understand Data Science models and techniques.
CO2	Interpret models in data using statistical analysis.
CO3	Prepare environment for distributed systems applications.
CO4	Implement real-life case studies.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Data Wrangling approaches – cleansing, pre-processing, transformation, normalization; Data Visualization Techniques, Probability Distributions, Normal Distribution- Binomial Distribution- Poisson Distributions Other Distribution, Basic Statistics, Correlation and Covariance, T-Tests,-ANOVA, p-vlaue, Determine the statistical significance of data. Supervised Learning techniques, Linear Models, Simple Linear Regression, -Multiple Regression, Generalized Linear Models, Logistic Regression, other Generalized Linear Models- Survival Analysis, Nonlinear Models, Splines. Unstructured data analysis.

Learning Resources:

Text Books:

1. Gareth James Daniela Witten Trevor Hastie and Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, 2013.
2. Beginning R The statistical Programming Language, Mark Gardener, Wiley, 2015.

6th Semester

CS2302 **4-0-0 (4)**

Deep Learning

Pre-requisites: **CS2202, CS2204**

Course Outcomes:

CO1	Use RNN, LSTM and GRU for sequential learning problems.
CO2	Design Autoencoders to solve Unsupervised Learning problems.
CO3	Apply Regularization methods Early stopping, data augmentation, dropout etc. for optimization.
CO4	Apply Classical Supervised methods CNN'S, FCN, RCNN etc. for Image Denoising, Segmentation and Object detection problems.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Biological Neurons, Artificial Neural Networks, McCulloch Pitts Neuron, Learning processes, Perceptron, Perceptron convergence theorem, XOR problem, Multilayer perceptron, Back Propagation (BP) Learning,Activation functions: Sigmoid, Linear, Tanh, ReLU, Leaky ReLU, SoftMax, loss functions; Optimizers: Gradient Descent (GD), Batch Optimization, Momentum Based GD, Stochastic GD, AdaGrad, RMSProp, Adam; Sequence to sequence models: Recurrent Neural Networks (RNN), Back propagation through time (BPTT), Vanishing and Exploding Gradients, LSTM, Bi-LSTM, GRU, NLP Applications. Convolutional Neural Network, Building blocks of CNN, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet; Semantic Segmentation, Instance Segmentation, FCN, Unet ; Object Localization, Region Proposal Networks, RCNN, RFCN, DeYolo; Advanced Deep Learning Architectures, Residual Network, Skip Connection Network, GoogleNet, DensenNet, MobileNet; Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Dropout, Drop connect; Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization; Learning Vectorial Representations of Words; Autoencoders : Unsupervised Learning with Deep Network, Autoencoders, Stacked, Sparse, Denoising Autoencoders, Variational Autoencoders; Transformers – BERT, GPT, ELMO, Visual Transformers.

Learning Resources:

Text Books:

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

Reference Books:

2. Charu C. Aggarwal, "Neural Networks and Deep Learning", Springer, 2018.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106184/

CS2304 **3-0-0 (3)**

Natural Language Processing

Pre-Requisites: **CS2204**

Course Outcomes:

CO-1	Understand the Text representation and Text pre-processing techniques.
CO-2	Understand language modeling with N-Grams.
CO-3	Apply syntactic parsing to produce parse trees.
CO-4	Design NLP Systems for Text Summarization, Classification and Translation.
CO-5	Evaluate the performance NLP 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	3	1	-	-	1	-	-	-	-	-	-	-	2	3	2	1
CO-2	3	2	-	-	2	-	-	-	-	-	-	-	3	2	2	1
CO-3	3	2	1	3	1	-	-	-	-	-	-	-	3	3	2	1
CO-4	-	-	3	-		-	-	1	-	-	-	-	2	3	2	1
CO-5	-	-	-	-	2	-	-	-	-	-	-	-	2	2	1	1

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

Syllabus:

Introduction and Basic Text Processing, Text Representation- one-hot encoding, TF-IDF, Bag-of-Words, Word2Vec, Glove Embedding, Text-Preprocessing- Tokenization, Stemming-Porters Stemming algorithm, Lemmatization, Normalization, Spell Checker- Spelling Correction, Edit Distance, Language Modeling- Probabilistic Language Modelling- N-gram Modelling, Language Models Evaluation, Text Parsing, Part-of-Speech Tagging, POS with Hidden Markov model (HMM), Text Summarization-Abstractive and Extractive Text Summarization. Text Classification- Text Classification Techniques – Topic Modelling, Sentiment Analysis, Named Entity Recognition(NER), Machine Translation, Introduction to Large Language Models (LLMs)

Learning Resources:

Text Books:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", 3rd Edition, 2008.
2. Uday Kamath, John Liu, James Whitaker, “Deep Learning for NLP and Speech Recognition”, Springer, 2020.

Reference Books:

1. Allen, James, "Natural Language Understanding", Second Edition, Benjamin/ Cumming, 1995.
2. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, “Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems”, O'REILLY, 2020.

CS2306 **0-1-4 (3)**

Product Development

Pre-Requisites: **CS2102**

Course Outcomes:

CO-1	Comprehend software development life cycle.
CO-2	Prepare SRS document for a project/product.
CO-3	Develop a prototype of the product.
CO-4	Evaluate the entire product and the product based on testing with user..
CO-5	Explore the scope for protecting novelty of the product through patent.

Course Articulation Matrix:

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

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

Syllabus:

Design Thinking process for Product Development: Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

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

Product Development: **User Interface (UI) and User Experience (UX) Design**: Principles of UI d esign, UX design best practices, Choosing a language of programming, creating intuitive interfaces, and optimizing user interaction, Agile methodologies for iterative design, identification of tools, usability testing, Debugging tools and techniques, usage of Simulators.

Gathering feedback, SDLC, collaboration between design and development teams, and integrating design processes with agile development practices,

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

Design Tools and Technologies, Project Management for Product Design, resource allocation, and risk management, privacy concerns, legal aspects and IPR Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights. , Case studies and real world applications, Business aspects of the product. Emerging product development-AI and IoT based products, Web and mobile based products.

Learning Resources:

Textbooks:

1. Pankaj Jalote, "Software Engineering Precise Approach" , Wiley Publishers, 2012.
2. Naresh Chauhan, “Software Testing- Principles and Practices”, Oxford University Press, Second Edition, 2016.
3. Martin Kleppmann, Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems, OREILLY, 2017
4. Marty Cagan, Inspired: How to Create Tech Products Customers Love, Wiley, 2018

Other Suggested Reading:

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

CS2382 **1-0-0 (0.5)**

Fractal Course II

Pre-Requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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

a. Structure: Lectures delivered by an expert from the Computer Science and Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).

b. Content: Topics covering current practices, case studies, technological advancements, and future trends.

c. Interactive Sessions: Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.

d. Assessment: the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

Learning Resources:

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

CS 2308 **0-1-2 (2)**

Deep Learning Lab

Pre-requisites: **CS2202, CS2204**

Course Outcomes:

CO1	Implement Multilayer Feed Backward Neural network on MNIT digits dataset
CO2	Build RNN, LSTM, BiLSTM Networks for time series analysis classification problems.
CO3	Design Autoencoders to solve Unsupervised Learning problems
CO4	Implement Classical Supervised Tasks for Image Denoising, Segmentation and Object detection problems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	-	3	3	2	3	1	-	-	1	2	1	-	1	2	-	1
CO2	2	1	-	2	2	1	-	-	2	1	1	-	-	-	-	3
CO3	1	2	2	-	1	2	-	-	1	1	-	2	2	-	1	1
CO4	3	-	2	3	3	2	-	-	2	3	1	-	3	1	3	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 a 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/Reference Books/Online Resources:

1. Ian Goodfelllow, Yoshua Benjio and Aaron Courville, Deep Learning, The MIT Press.
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3. Simon Haykin, “Neural Networks, A Comprehensive Foundation”, 2nd Edition, Addison Wesley Longman, 2001.

CS2310 **0-1-2 (2)**

Natural Language Processing Lab

Pre-Requisites: **CS2204**

Course Outcomes:

CO-1	Understand the Text representation and Text pre-processing techniques
CO-2	Understand language modeling with N-Grams.
CO-3	Apply syntactic parsing to produce parse trees
CO-4	Design NLP Systems for Text Summarization, Classification and Translation
CO-5	Evaluate the performance NLP 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	3	1	-	-	1	-	-	-	-	-	-	-	2	3	2	1
CO-2	3	2	-	-	3	-	-	-	-	-	-	-	3	2	2	1
CO-3	3	2	1	3	1	-	-	-	-	-	-	-	3	3	2	1
CO-4	-	-	3	-	3	-	-	1	-	-	-	-	2	3	2	1
CO-5	-	-	-	-	2	-	-	-	-	-	-	-	2	2	1	1

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

Syllabus:

1. Implement the Text Representation Techniques
    a. One-hot encoding
    b. TF-IDF
    c. Bag-of-Words
2. Implement the Text Pre-processing Techniques
    a. Tokenization
    b. Lemmatization
    c. Normalization
3. Implement the Porters Stemming algorithm
4. Implement the Spellchecker
5. Implement Hidden Markov model (HMM) for POS tagging
6. Implement the probabilistic language model
7. Write a program to perform the Text Summarization
    a. Abstractive
    b. Extractive
8. Write a program to perform the Text Classification
    a. PoS Tagging
    b. Sentiment Classification
9. Write a program to perform the Named Entity Recognition (NER)
10. Download and Install the LangChain and use LangChain to perform different NLP tasks.

Learning Resources:

Text Books:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", 3rd Edition, 2008.
2. Uday Kamath, John Liu, James Whitaker, “Deep Learning for NLP and Speech Recognition”, Springer, 2020.

Reference Books:

1. Allen, James, "Natural Language Understanding", Second Edition, Benjamin/ Cumming, 1995.
2. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, “Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems”, O’Reily, 2020.

7th Semester

CS2401 **3-0-0 (3)**

High Performance Computing

Pre-Requisites: **CS2208, CS2305**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

Introduction: 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.
3. Joseph Jaja, "An Introduction to Parallel Algorithms", Addison-Wesley, 1992.

Reference Books:

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

CS2403 **0-1-2 (2)**

High Performance Computing Lab

Pre-Requisites: **CS2208 – Operating Systems Design, CS2305 – Computer Networks**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

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

Reference Books:

1. Web Materials

CS2489 **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	PSO-4
CO-1	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-
CO-2	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-
CO-3	2	-	2	-	-	3	3	-	2	3	-	3	-	-	-	-

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

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

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

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

Evaluation Criteria:

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

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

Evaluation Criteria-CO Mapping

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

CS2495 **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	PSO-4
CO-1	3	3	3	3	3	-	-	-	2	1	-	3	-	-	-	-
CO-2	2	2	2	2	2	-	-	-	3	2	3	3	-	-	-	-
CO-3	2	2	2	2	2	-	-	-	3	2	3	3	-	-	-	-
CO-4	1	1	1	1	1	-	-	-	3	3	-	-	-	-	-	-

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

Description:

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

Evaluation Criteria:

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

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

Evaluation Criteria-CO Mapping

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

CS2491 **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	PSO-4
CO-1	3	3	3	3	3	-	-	-	-	-	-	3	-	-	-	-
CO-2	2	2	2	2	2	-	-	3	3	-	3	3	-	-	-	-
CO-3	-	-	-	-	-	3	3	-	-	-	-	3	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-

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

Description:

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

Evaluation Criteria:

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

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

Evaluation Criteria-CO Mapping

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

8th Semester

CS2498

0-0-0 (6)

Major Project

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Description:

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

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

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

Evaluation Criteria:

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

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

Evaluation Criteria-CO Mapping

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

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

Professional Electives

CS2321 **3-0-0 (3)**

Business Intelligence

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand business intelligence and its application.
CO-2	Elucidate the role of business intelligence.
CO-3	Analyze the Key Performance Indicators and Corporate Performance Indicators.
CO-4	Examine the various models of business intelligence in organizational success.

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

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

Syllabus:

Overview of managerial, strategic and technical issues associated with Business Intelligence and Data Warehouse design, implementation, and utilization. Principles of dimensional data modeling, techniques for extraction of data from source systems, data transformation methods, data staging and quality, data warehouse architecture and infrastructure, and the various methods, for information delivery. Critical issues in planning, physical design process, deployment and ongoing maintenance. The course will use state-of-the–art data warehouse and OLAP software tools to provide hands-on experience in designing and using Data Warehouses and Data Marts. Gathering of strategic decision-making requirements from businesses, develop key performance indicators (KPIs) and corporate performance management metrics using the Balance Scorecard, and design and implement business dashboards.

Learning Resources:

Text Books:

1. Efraim Turban, Ramesh Sharda, Jay Aronson, David King :Business Intelligence, Pearson Education, 2007.
2. Ramesh Sharda, Dursun Delen , Efraim Turban, Business Intelligence, Analytics, and Data Science: A Managerial Perspective, Pearson Edition, 4th Edition 2017

CS2323 **3-0-0 (3)**

Data Mining Algorithms

Pre-Requisites: **Nil**

Course Outcomes:

CO-1	Analyze Algorithms for frequent Item sets.
CO-2	Analyze Algorithms for sequential patterns.
CO-3	Determine patterns from time series data.
CO-4	Develop algorithms for graph patterns.
CO-5	Apply Graph mining algorithms to Web Mining.

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

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

Syllabus:

Knowledge Discovery Process. Data Pre-processing Techniques. Data Mining Tasks. Basic concepts of Association Rule Mining, Frequent Item set mining, Mining various kinds of association rules, Sequential Pattern Mining concepts, primitives, scalable methods; Transactional Patterns and other temporal based frequent patterns, Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis; Graph Mining, Mining frequent subgraphs, finding clusters in large graphs; Web Mining, Mining the web page layout structure, mining web link structure, Automatic classification of web documents and web usage mining.

Learning Resources:

Text Books:

1. Jiawei Han and M Kamber, Data Mining Concepts and techniques, Morgan Kaufmann Publishers In, 2022; Fourth Edition.
2. Chris Chatfield, The Analysis of Time Series: An Introduction, Chapman & Hall/CRC, 2003, Sixth Edition.
3. Bing Liu, Web Data Mining, Springer, 2011, Second Edition.

Reference Books:

1. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne and Vipin Kumar, Introduction to Data Mining, Pearson, 2018, Second Edition.
2. G. Dong and J Pei, Sequence Data Mining, Springer, 2007, First Edition.

CS2325 **3-0-0 (3)**

Information Coding Theory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand Shannon's noisy coding theorem, Shannon capacity and entropy.
CO-2	Analyze the channel performance using information theory.
CO-3	Design of error correcting codes and decoding algorithms.
CO4	Design of network coding algorithms for communication networks.
CO5	Analyze coding techniques for data storage, security and compression.

Course Articulation Matrix:

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

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

Syllabus:

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

Learning Resources:

Text Books:

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

Reference Books:

1. F. J. MacWilliams and N.J. Sloane: Theory of Error Correcting Codes, Parts I and II, North-Holland, Amsterdam, 1977.
2. Tom Richardson, RudigerUrbanke, Modern Coding Theory, Cambridge University Press, 2008
3. John b. Anderson and Seshadri Mohan, Source and Channel Coding: An Algorithm Approach, Springer, 1991.
4. G. Kabatiansky, E. Krouk and S. Semenov, Error Correcting Coding and Security for Data Networks, John Wiley & Sons Ltd., 2005
5. T. Ho and D. S. Lun, Network Coding: An Introduction, Cambridge University Press, Cambridge, U.K., April 2008.

CS2327 **3-0-0 (3)**

Statistical Learning

Pre-Requisites: CS1101

Course Outcomes:

CO-1	Learn modern statistical techniques for modeling and drawing inferences from large data sets.
CO-2	Learn to use visual and numerical diagnostics to assess the soundness of models.
CO-3	Understand the concepts of classification, regression, Online Learning, Transfer Learning, Machine Learning (ML) and Pattern Recognition (PR).
CO-4	Learn how statistical distribution in datasets affect performance of ML and PR techniques.
CO-5	Compare the performance of two learning 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	3	2	2	–	-	–	2	2	2	2	-	3	-	2
CO-2	3	2	3	1	2	–	-	–	2	2	2	2	-	3	-	2
CO-3	3	2	3	2	2	–	-	–	1	2	2	2	-	3	-	3
CO-4	3	2	2	2	2	–	–	–	2	2	2	2	-	3	-	2
CO-5	3	2	3	2	2	–	–	–	2	2	2	2	-	3	-	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

The Learning Problem: The learning problem: Risk functions, Well-posed and ill-posed problems; Supervised Learning Vs Function Approximation; Bias Variance Tradeoff; Curse of Dimensionality.

Linear Models for Regression: Least Squares Vs Nearest Neighbors; Subset Selection methods; Shrinkage Methods: Ridge Regression, LASSO, Group LASSO, Least Angle Regression (LAR).

Pattern Recognition and Machine Learning Basics: Bayes'; PCA and LDA; Perceptron Learning; Decision Boundaries and Discriminant Functions; Kernel density; Mixture models; Hierarchical clustering.

Regularization: Tikhonov Regularization; Iterative Regularization via Early Stopping; Empirical and Structural Risk Minimization.

Regularization Networks and SVM: RKHSs, Mercer's Theorem, Representer theorem, VC Dimension; Hard & Soft margin SVMs; Multiple Kernel Learning, Risk/regret bounds for SVMs, Kernel regression, Convex losses for classification.

Advanced Topics (Selected topics): Sparse Representation Classifier: BOW & Dictionary Learning; Proximal Gradient; ADMM; Basis Pursuit (BP), M-BP, IrM-BP, M-FOCUSS; M-SBL; Auto-encoder & Deep Learning, Transfer Learning & Domain Adaptation, On-line Learning.

Target Applications: Face Recognition and Verification, Video event representation, CBIR in Large Scale Dataset (e.g. ImageNet), Fraud and Rumor Detection in Social Media, DNA Sequencing.

Learning Resources:

Text Books:

1. V. N. Vapnik; Statistical Learning Theory. Wiley, 1998.
2. T. Hastie, R.Tibshirani, J. Friedman, "The Elements of Statistical Learning: Data Mining, Inference and Prediction", Springer Series in Statistics, 2009.
3. Kevin R Murphy, "Machine Learning - A Probabilistic Perspective", The MIT Press, 2012.
4. T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning, Springer 2001.

References:

1. Michael J. Kearns and Umesh Vazirani; An Introduction to Computational Learning Theory; The MIT Press, 1994.
2. Journal of the Royal Statistical Society: Series B (Statistical Methodology).
3. Foundations and Trends in Machine Learning; Now Publishers Inc.
4. Journal of Machine Learning Research; JMLR, Inc. and Microtome Publishing (United States).
5. Bishop, Christopher M. "Pattern recognition and machine learning", Springer, 2006.
6. R.O. Duda, P.E. Hart and D.G. Stork "Pattern Classification (2nd ed.)", John Wiley & Sons, Inc., 2003.

CS2322 **3-0-0 (3)**

Advanced Databases

Pre-Requisites: **CS2206**

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:

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

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.

Reference Books:

1. Avi Silberschatz, Henry F. Korth and S. Sudarshan, Database System Concepts, Seventh Edition, McGraw-Hill, 2019.

CS2324 **3-0-0 (3)**

Big Data Analytics

Pre-Requisites: **CS2323**

Course Outcomes:

CO-1	Understand big data challenges in different domains including social media, transportation, finance and medicine.
CO-2	Analyze the capability of No-SQL systems.
CO-3	Apply machine learning algorithms for data analytics.
CO-4	Analyze MAP-REDUCE programming model for better optimization.
CO-5	Analyze the capability of Stream Data Processing 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	1	1	-	-	1	-	-	-	-	-	-	1	2	3	2	1
CO-2	2	2	2	1	3	-	-	-	-	-	-	1	3	2	2	1
CO-3	3	2	2	3	1	1	-	2	-	-	-	2	3	3	2	1
CO-4	1	2	3	1	3	-	-	1	-	-	-	2	2	3	2	1
CO-5	2	1	1	1	2	1	-	-	-	-	-	1	2	2	1	1

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

Syllabus:

Overview of Big Data Analytics: Big Data Characteristics, Big Data Challenges, Big Data Analytics system Architecture, Big Data Storage Technologies, Big Data Analytics Life Cycle; No SQL databases: Introduction to No SQL databases, Types of No SQL databases, CAP Theorem, Replication & Shading, MongoDB basics; Overview of Hadoop, Hadoop Ecosystem, Reading and Writing Files on Hadoop Distributed File System. Map Reduce basics, Map Reduce Algorithm Design. Graph Algorithms, Data Mining with Big Data, Stream Data Processing, Stream Data Processing System and Tools, Overview of Spark, Spark SQL-Mllib-GraphX, Apache Kafka, Big Data Analytics in Industry Verticals, Operationalizing Basic Data Analytic Methods Using R, Analytics for Unstructured Data.

Learning Resources:

Text Books:

1. Jure Leskovec, Anand Rajaraman, J D Ullman, Mining Massive Datasets, Cambridge University Press, 2nd Edition, 2014.
2. Jimmy Lin and Chris Dyer, Data Intensive Text Processing with Map Reduce, Morgan & Claypool Publishers,1st Edition, 2010.

Reference Books:

1. Bill Franks, Taming The Big Data Tidal Wave, 1st Edition, Wiley, 2012.
2. Johannes Ledolter, Data Mining and Business Analytics with R, Wiley, 2013.

CS2326 **3-0-0 (3)**

Database Security

Pre-Requisites: **CS2323**

Course Outcomes:

CO-1	Identify access control methods for secure database application development.
CO-2	Analyze vulnerabilities in the database applications.
CO-3	Design and evaluate methods for database intrusion detection.
CO-4	Apply security audit methods.
CO-5	Design secure database schema.

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

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

Syllabus:

Database Basics: Overview of Relational Model, SQL, Building of database, Manipulation of data. Goals of Database Security, access points of database security, database security levels, and menaces to databases. Database security methods and methodologies, Security controls: flow control, inference control, access control, Database Application Security models – Types of users, access matrix model, access modes model, commonly used application types. Classes of access control: Discretionary access control (DAC), Mandatory access control (MAC), and Role-based Access control (RBAC); Discretionary Access Control (DAC) mechanisms such as capabilities, profiles, access control lists, passwords, and permission bits. RBAC-based security models feature User role assignment, Support for role relationships and Constraints, and Assignable privileges. MAC-based security models. Implementing Fine-Grained access controls with views, Virtual Private databases: need for VPDs, Implementing VPD using views, The Database Security Design includes the controls that will be implemented to restrict users from accessing information, based on how the information is classified and the security model.

Learning Resources:

Text Books:

1. Michael Gertz and Sushil Jajodia, Handbook of Database Security Applications and Trends, Springer, 2008.
2. Silvano Castano, Fugini, Martella, Samarati , Database Security, Addison Wesley, 1994.
3. Ben-Natan, R. B., Implementing Database Security and Auditing: Includes Examples for Oracle, SQL Server, Db2 Udb, and Sybase, Digital Press, 2005.
4. Mike Shema, Hacking Web Apps Detecting and Preventing Web Application Security Problems, Syngress, 2012.

CS2328 **3-0-0 (3)**

Formal Verification of Machine Learning Models

Pre-Requisites: CS2204

Course Outcomes:

CO-1	Model the state of a software component using the unifying concept of mathematical relation.
CO-2	Design of automatic verification tools to establish the validity of a given software property.
CO-3	Apply automatic software verification tools based on model checking.
CO-4	Design tools for the deductive verification of programs annotated with contracts.

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Formal Verification: Overview of formal verification, Importance and applications in software engineering and ML Types of properties to verify: safety, security, fairness, robustness;

Mathematical Foundations: Propositional and predicate logic, Temporal logic: Linear Temporal Logic (LTL) and Computation Tree Logic (CTL), Basics of model checking;

Formal Methods for Verification: Model checking: concepts and algorithms, Theorem proving: introduction and tools (e.g., Coq, Isabelle), SAT and SMT solvers;

Machine Learning Model Basics: Overview of machine learning models, Training and evaluation of ML models, Common architectures: decision trees, SVMs, neural networks;

Challenges in Verifying ML Models: Non-linearity and high dimensionality in ML models, Interpretability vs. accuracy, Robustness to adversarial attacks;

Techniques for Verifying ML Models: Abstract interpretation, Symbolic execution, Reachability analysis

Verification of Neural Networks: Verification of feedforward neural networks, Techniques for verifying recurrent neural networks, Case studies and tools (e.g., Marabou, Reluplex),

Adversarial Robustness: Adversarial examples in ML, Techniques for generating and defending against adversarial attacks Formal methods for ensuring robustness;

Probabilistic Verification: Probabilistic model checking, Bayesian networks and probabilistic graphical models Applications in ML model verification;

Fairness and Bias in ML Models: Definitions and types of biases in ML, Techniques for verifying and mitigating bias, Ethical considerations and case studies;

Scalability Issues: Scalability challenges in formal verification of large ML models, Techniques for improving scalability, Case studies and practical solutions;

Learning Resources:

Text Books:

1. Christel Baier and Joost-Pieter Katoen, Principles of Model Checking.
2. David L. Poole and Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents.

Reference Books:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning" (Selected Chapters).

CS2330 **3-0-0 (3)**

Information Retrieval

Pre-requisites: **CS1102, CS2323**

Course Outcomes:

CO-1	Understand the concepts of information retrieval and their application to locate relevant information in large corpus of documents.
CO-2	Design and develop information retrieval systems for retrieval from web and other resources.
CO-3	Develop skills to analyze the performance of retrieval systems.
CO-4	Explore real-life case studies in different domains.

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Information Retrieval (IR) problem, Search and Browse, Efficient text indexing, inverted index, Metrics – relevance, effectiveness, precision, recall; Term vocabulary and postings lists, Dictionaries and tolerant retrieval, Index construction, Storage of indices, Storage of documents, Inverted file creation, Dictionary compression techniques, Inverted file compression techniques, Document compression techniques, Scoring, term weighting and the vector space model, Retrieval models: Probabilistic IR - the binary independence model; Boolean and vector-space retrieval models; Evaluation and interface issues, IR techniques for the web, including crawling, link-based algorithms, and metadata usage Document clustering and Document classification -, Text classification (Naive Bayes, KNN, decision boundaries, Support Vector Machine), Clustering in information retrieval, Matrix decompositions and latent semantic indexing, Traditional and machine learning-based ranking approaches; personalization, link analysis, information visualization, Parallel and distributed IR, Multimedia IR – Search and Indexing.

Learning Resources:

Text Books:

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

Reference Books:

1. D. Grossman and O. Frieder, "Information Retrieval: Algorithms and Heuristics", Springer, 2004.
2. R. Baeza-Yates and B. Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, ACM Press, 1999.

CS2332 **3-0-0 (3)**

Soft Computing

Pre-Requisites: **None**

Course Outcomes:

CO1	Understanding of optimizations problems, comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.
CO2	Understand the fundamental theory and concepts of neural networks and Identify different neural network architectures, algorithms, applications and their limitations.
CO3	Apply genetic algorithms and neural networks to solve real world problems.
CO4	Apply soft computing techniques to solve engineering and other societal problems.

Syllabus:

Overview of course and Basic of Soft Computing, Introduction of Neural Networks, Learning Process and Learning Task, Supervised Learning – Single and Multi – Layer Network, Associative Memory, Self-organizing Maps, Neuro-Dynamics, Hopfield Network, Fuzzy Logic and Systems- Fuzzy Sets and Membership Functions, Operations on Fuzzy Sets, Fuzzification. Fuzzy Numbers- Uncertain Fuzzy Values, Fuzzy Numbers and its L-R representation, Operations on Fuzzy Numbers. Fuzzy Relations, Fuzzy Inference Systems- Architecture of Fuzzy Inference System, Fuzzy Inference Rules and Reasoning, Defuzzification. Applications of Fuzzy Logic, Genetic algorithms and evolutionary computation. Applications of Genetic Algorithms & Hybrid Systems.

Learning Resources:

Text Books:

1. R.A. Aliev, R.R. Aliev, Soft Computing and Its Applications, World Scientific Publications, 2001.
2. Roger Jang, Tsai Sun, Eiji Mizutani, Neuro-Fuzzy and Soft Computing: A computational Approach to Learning & Machine Intelligence, PHI, 2008.
3. Simon Haykin, Neural Network: A Comprehensive Foundation, PHI, 1999.
4. Kishan Mehtrotra, S. Ranka, Elements of artificial Neural Networks, Penram International Publishing (India), 2009
5. Timothy Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, McGraw-Hill, 2010.
6. Bart Kosko, Neural Networks and Fuzzy Systems, PHI, 1994.

CS2334 **3-0-0 (3)**

Speech Technology

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the concepts of Speech Signals.
CO-2	Apply the basic concepts of Digital Signal Processing.
CO-3	Use signal processing methods to solve a given problem.
CO-4	Create an approach for speech recognition.
CO-5	Apply the principles of speech technology to solve a real-world engineering problem.

Course Articulation Matrix:

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

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

Syllabus:

Overview of Speech Technology: What is Speech Technology? Why is it important? Its applications and issues

Speech Production: Mechanism of speech production; Categories of sounds; Sound units in Indian languages

Nature of Speech Signal: Source-system characteristics; Segmental and suprasegmental features; Temporal and spectral parameters for sound units in Indian languages

Basics of Digital Signal Processing: Signals and systems; Discrete Fourier transform; Digital filtering; Stochastic processes

Speech Signal Processing Methods: Short-time spectrum analysis; Spectrograms; Linear prediction analysis; Cepstrum analysis

Speech Recognition: Isolated word recognition; Connected word recognition Continuous Speech Recognition; Speech recognition problem; Hidden Markov models

Other Applications: Word spotting; Speaker recognition; Speech enhancement; Speech synthesis; Practical issues in speech technology

Learning Resources:

Text Books:

1. Lawrence R Rabiner, Ronald W Schafer, Theory and Application of Digital Speech Processing, Pearson, 2011, 1st Edition.
2. Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, Fundamentals of Speech Recognition, Pearson, 2009, 1st Edition.
3. Xuedong Huang, Alex Acero, Hsiao-wuen Hon, Spoken Language Processing: A guide to Theory, Algorithm, and System Development, Prentice Hall, 2001.

Reference Books:

1. Alan Oppenheim, Ronald Schafer, Discrete-Time Signal Processing, Pearson, 2009, 3rd Edition.
2. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Pearson Prentice Hall, 2001.
3. Lawrence R Rabiner, Ronald W Schafer, Digital Processing of Speech Signals, Pearson Education India, 2003, 1st Edition.
4. Douglas O'Shaughnessy, Speech Communications: Human and Machine, Universities Press, 2001.

CS2336 **3-0-0(3)**

Time Series and Text Mining

Pre-requisites: CS2323

Course Outcomes:

CO1	Understand the importance of time series and text data.
CO2	Enhance analytical skills for mining time series and text data.
CO3	Develop skills to leverage sequence patterns.
CO4	Create real-life case studies using text data.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Time Series Similarity Measures - Euclidean Distances and Lp Norms, Dynamic Time Warping, Longest Common Subsequence Similarity, Probabilistic methods, General Transformations, Mining Time series Data -Indexing (Query by Content), Classification, Clustering, Forecasting, Summarization, Anomaly detection, Segmentation. Time Series representations - Discrete Fourier Transform, Discrete Wavelet Transform, Singular Value Decomposition, Piecewise Linear Approximation, Piecewise Aggregate Approximation, Adaptive Piecewise Constant Approximation, Symbolic Aggregate Approximation, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis; Text Mining – Overview of natural language processing techniques and text representation, Word association mining, Text based Similarity measures, Information extraction from text, NER, Text Classification, Text Clustering, Text Summarization, Dimensionality Reduction and Topic Modeling - Latent Semantic Indexing, Latent Dirichlet Allocation, Short Text Understanding. Probabilistic Models for Text Mining, Mining Text Streams, Opinion Mining and Sentiment Mining, Text Mining applications.

Learning Resources:

Text Books:

1. Data Mining Concepts and Techniques - Jiawei Han & Micheline Kamber, Morgan Kaufmann Publishers, Elsevier, 2nd Edition, 2006.
2. Introduction to Data Mining Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education.
3. Charu C. Aggarwal, ChengXiang Zhai, Mining Text Data, Springer, 2014.

Reference Books:

1. Jure Leskovec, Anand Rajaraman, Jeffrey D. Ullman, Mining of Massive Datasets, 2nd Edition, Cambridge University Press & Assessment.

Online References:

1. Mining Time Series Data, Chapter 1, https://cs.gmu.edu/~jessica/BookChapterTSMining.pdf.

CS2421 **3-0-0 (3)**

Computer Vision and Image Processing

Pre-Requisites: **None**

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.

CS2423 **3-0-0 (3)**

Intruder Detection Systems

Pre-Requisites:

Course Outcomes:

CO-1	Explore the concepts of Network Protocol Analysis and analyze information systems and networked systems.
CO-2	Identify system vulnerabilities and attacks and troubleshoot system problems.
CO-3	Design and Develop intrusion detection systems& intrusion prevention systems and identify their signatures.
CO-4	Select technologies and tools for intrusion detection and intrusion prevention.
CO-5	Exercises and use cases for testing and evaluating various IDS 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	–	1	-	-	-	1	-	2	-	-	-	-	-	-	-	–
CO-2	2	1	-	1	-	1	-	1	-	-	-	2	-	1	1	2
CO-3	1	1	1	1	2	-	1	-	1	2	-	-	1	1	-	2
CO-4	-	2	-	-	1	-	-	-	1	2	-	1	-	1	-	1
CO-5	2	-	1	2	2	-	1	-	-	-	1	-	2	-	1	1

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

Syllabus:

Firewall Planning and Design, Developing a Security Policy, System Configuration Strategies, Working with Proxy Servers and Application-Level Firewalls, Authenticating Users, Encryption and Firewalls.

Intrusion detection, Audit, Internal and external threats to data, attacks, Information sources - Host-based information sources, and Network-based information sources; Types and classification of IDS.

Intrusion Prevention Systems, Network Systems, Network IDs protocol IDs, Hybrid IDs, Analysis schemes, models for intrusion analysis, techniques, mapping responses to policy vulnerability analysis, credential analysis non-credential analysis IDS using SNORT, NIDS, NNID and HIDS;

Discovery and Detection: Identify IDS signatures such as anomaly detection, pattern matching, and statistical analysis; Machine Learning models for IDS, Distributed IDS models; Architecture models of Intrusion Detection and intrusion prevention.

Learning Resources:

Text Books:

1. Rafeeq Ur Rehman, Intrusion Detection Systems with Snort Advanced IDS Techniques Using Snort, Apache, MySQL, PHP, and ACID, Prentice Hall, Pearson, 2003.
2. Christopher Kruegel, FredrikValeur, Giovanni Vigna, "Intrusion Detection and Correlation Challenges and Solutions", Springer, 2005.
3. Carl Endorf, Eugene Schultz and Jim Mellander, "Intrusion Detection & Prevention", Tata McGraw-Hill, First edition, 2006.

CS2425 **3-0-0 (3)**

IoT Data Processing

Pre-Requisites: CS2201, CS2204, CS2302, CS2324, CS2305

Course Outcomes:

CO-1	Investigate suitable technologies for the processing of IoT data.
CO-2	Compare and assess various IoT data processing models and techniques in IoT systems.
CO-3	To understand the performance of IoT systems by optimizing latency, speed, and energy using Edge Analytics.
CO-4	Identify security vulnerabilities in IoT applications in the OT and IT data 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	2	3	-	-	-	-	-	-	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	2	2	-	2	2	2	2	2	2	2	2
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, Architecture of IoT, Integration of OT and IT technologies, IoT Data Flow, IT Data Processing, Challenges of IT data processing,

IoT Data Processing Topologies, Data Format- Structured data, Unstructured data, Importance of Processing in IoT, Processing Topologies- On-site processing, Off-site processing, IoT Device Design and Selection Considerations, Processing Offloading-Offload location, Offload decision making, Offloading considerations

IoT data processing using Edge Analytics-Edge and Fog Computing in IoT, Edge analytics-based IoT solution, Key benefits of edge analytics, Privacy, Latency, Reliability, Edge analytics architectures, IoT Edge-based edge analytics architecture, Edge analytics with machine learning

Communications Protocols Used in Edge Analytics- Wi-Fi communication for edge analytics, Bluetooth for edge analytics communication, Cellular technologies for edge analytics communication, Long-distance communication using LoRa and Sigfox for edge analytics

Cloud Computing in IoT- Cloud service providers, Storage, Processing, Virtual machines, Containers, Serverless computing, Everything as a service

Security and Privacy in an Edge Analytics- IoT security, Types of attacks against our edge analytics applications, Vulnerability issues, Protecting our edge analytics applications, Security Center for IoT using cloud, Monitoring and auditing the edge analytics applications

Text Books:

1. Sudip Misra, Anandarup Mukherjee, and Arijit Roy. Introduction to IoT. Cambridge University Press, 2021.
2. Dow, Colin. Hands-On Edge Analytics with Azure IoT: Design and Develop IoT Applications with Edge Analytical Solutions Including Azure IoT Edge. Packt Publishing Ltd, 2020.
3. Gao, Jie, Mushu Li, and Weihua Zhuang. Connectivity and Edge Computing in IoT: Customized Designs and AI-based Solutions. Springer, 2021.

Reference Books:

1. Perros, Harry G. An Introduction to IoT Analytics. Chapman and Hall/CRC, 2021.

CS2427 **3-0-0 (3)**

Medical Image Processing

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand image processing Techniques
CO-2	Apply restoration and segmentation techniques in medical images.
CO-3	Understand the representations of features and classification methods
CO-4	Apply Deep learning methods for medical data analysis and Generative models for generate synthetic 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	2	1	1	2	2	–	1	–	–	1	–	–	2	1	2	2
CO-2	3	2	2	3	3	2	–	–	1	1	1	–	3	2	3	2
CO-3	2	1	1	2	2	–	1	–	–	1	–	–	3	2	2	1
CO-4	3	2	2	3	3	2	–	–	1	1	1	–	3	2	3	2

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

Syllabus:

Introduction to medical imaging, Image Sensing and Acquisition, Image Sampling and Quantization, Various modalities of Medical Imaging-CT, MRI, PET; Basic image processing techniques- medical image enhancement, image histogram equalization, image edge enhancement, noise reduction, filtering and image restoration; Image registration - Rigid and Non-Rigid models, Application and demonstration; Image representations, Classification methods, Clustering methods; Image segmentation - Histogram-based methods, Statistical shape model, PDE based methods, Multi-scale segmentation, semi-automated methods, clustering-based methods, classification-based methods; multi-model segmentation application and demonstration; Computer Aided Diagnosis – Case Study; Deep Learning for Medical image analysis – 3D Convolutional Neural Networks; Deep Learning for Medical image analysis – Generative models for synthetic data.

Learning Resources:

Text Books:

1. Digital Image Processing, Second edition Rafael C. Gonzalez, Richard E. Woods, (Prentice Hall)
2. https://nptel.ac.in/courses/102106094
3. Jerry L. Prince and Jonathan Links, "Medical Imaging Signals and Systems", First Edition, Prentice Hall, 2005.

Reference Books:

1. C Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. Anil.K.J “Fundamentals of Digital Image Processing”, Prentice Hall of India Pvt. Ltd., New Delhi, 1995.
3. S Sridhar, Digital Image Processing Second Edition, Oxford University Press, 2016.

CS2429 **3-0-0 (3)**

Quantum Computing

Pre-Requisites: **MA1161, CS1101, CS1106**

Course Outcomes:

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

Course Articulation Matrix:

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

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

Syllabus:

Preliminaries: Review of linear algebra and complex numbers.

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

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

Learning Resources:

Text Books:

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

Reference Books:

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

Other Suggested Readings:

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

CS2431 **3-0-0 (3)**

Recommendation Systems

Pre-Requisites: CS2204

Course Outcomes:

CO-1	Learning fundamental concepts and algorithms in recommendation systems.
CO-2	Apply recommendation techniques to solve real-world problems in various domains.
CO-3	Evaluate and optimize recommendation systems using appropriate metrics.
CO-4	Explore and understand advanced topics and future trends in recommendation systems.
CO-5	Enhance critical thinking and problem-solving skills through analyzing case studies and tackling complex recommendation system challenges.

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

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

Syllabus:

Introduction to recommendation systems, types and applications of recommendation systems, data collection and preprocessing methods, user-based collaborative filtering and similarity measures, item-based collaborative filtering and implementation, matrix factorization techniques including Singular Value Decomposition (SVD), content-based filtering methods and feature extraction, hybrid recommendation systems, evaluation metrics, scalability challenges and optimization techniques, deep learning approaches for recommendation systems including neural collaborative filtering and autoencoders, Confidence in Recommender Systems, Trust based Recommender Systems, Justified Recommender Systems, Case studies and advanced topics like context-aware and multi-criteria recommendations, and project work with presentations to apply knowledge in real-world scenarios.

Learning Resources:

Text Books:

1. Recommender Systems: An Introduction" by Dietmar Jannach, Markus Zanker, Alexander Felfernig, and Gerhard Friedrich
2. Introduction to Recommender Systems" by Charu C. Aggarwal

Reference Books:

1. Mining of Massive Datasets" by Jure Leskovec, Anand Rajaraman, and Jeff Ullman
2. Matrix Factorization Techniques for Recommender Systems" by Yehuda Koren, Robert Bell, and Chris Volinsky
3. Deep Learning for Recommender Systems" by Nick Pentreath

Other Suggested Readings:

1. Research Papers.

CS2433 **3-0-0 (3)**

Sequential Decision System

Pre-requisites: **None**

Course Outcomes:

CO-1	Understand the Online Learning methods.
CO-2	Design a Halving and Hedge algorithms.
CO-3	Understand the Online linear optimization and convex optimization.
CO-4	Build a different type of Multi armed Bandits.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Online Learning, Halving algorithm, Online Machine Learning; Perceptron and Winnow, Intro to Regret; Online learning with expert advice - Hedge algorithm, Online linear optimization, Online convex optimization; Online learning summary, Introduction to Multi armed Bandits - EXP3, Contextual MAB - EXP4, Stochastic MAB, Epsilon Greedy, Explore then commit, Stochastic MAB, UCB, Thompson Sampling, Stochastic MAB - Linear Bandits - LinUCB algorithm; MAB summary, Introduction to Reinforcement Learning - Markov Decision Process, Q-learning.

Learning Resources:

Text Books:

1. R. S. Sutton and A. G. Barto. Reinforcement Learning - An Introduction. MIT Press. 1998.
2. Marco Wiering, Martijn Otterlo, Reinforcement Learning: State-of- The-Art, Springer, 2012.

Reference Books:

1. Peter Norvig and Stuart J. Russell, Artificial Intelligence: A Modern Approach, Third Edition, Prentice Hall.
2. Warren B.Powell, Reinforcement Learning and Stochastic Optimization: A unified frameworj for sequential decisions, Jphn Wiley and Sons, Hoboken, 2022.

CS2435 **3-0-0(3)**

Social Media Analytics

Pre-requisites: **CS2204**

Course Outcomes:

CO1	Understand the importance of social media and networks.
CO2	Enhance analytical skills for analyzing social media and networking data.
CO3	Develop skills to leverage extended enterprise data.
CO4	Create real-life case studies using social media data.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Detailed syllabus:

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

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

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

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

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

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

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

Learning Resources:

Text Books:

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

CS2432 **3-0-0 (3)**

AI in Robotics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the fundamentals of robotics and AI.
CO-2	Develop skills in robot programming and control.
CO-3	Implement robot sensing and vision.
CO-4	Implement machine learning and deep learning techniques for robotics.
CO-5	Implement real-world robotic 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	3	3	1	2	–	2	–	–	–	–	–	–	2	2	2	2
CO-2	3	3	3	3	2	1	–	–	–	–	–	3	3	3	3	3
CO-3	3	3	3	3	3	2	2	1	3	2	3	3	3	3	3	3
CO-4	3	3	3	3	3	2	2	1	3	2	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

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

Syllabus:

Introduction to Robotics: Types of robots; History and science of robotics; Robot arm kinematics and dynamics; Manipulator trajectory planning and motion control; Robot sensing.

Robot Arm Kinematics and Dynamics: The direct and inverse kinematics problem. Lagrange-Euler formulation; Newton-Euler formulation; Generalized D'Alembert equations of motion.

AI in Robotics: Searching Techniques: uninformed search strategies, informed (heuristic) search strategies, local search algorithms, searching in non-deterministic and partially observable environment, adversarial search, Temporal Probability models and inference in temporal models: filtering, prediction, smoothing, most likely explanation, Dynamic Bayesian Networks, Hidden Markov Model, Kalman Filter, Extended Kalman Filter, Particle Filter, Learning Probabilistic Models; Decision making: Markov Decision Processes (MDPs), Partially Observable MDPs (POMDPs); Learning: Introduction to supervised learning, unsupervised learning, and reinforcement learning

Robot sensing and Vision: Robotic vision sensors and their interfacing; Fundamentals of Computer Vision: Image accusation and representation, image transformation, filtering, restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC; Position and Orientation: Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment; Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation, geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth), Analysis and parameter studies; Recognition and Interpretations: Concepts of machine learning and deep learning, sequence modeling, Learning for robotic

vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation

Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.

Learning Resources:

Text Books:

1. Fu K S, Gonzalez R C, George Lee C S, Robotics: Control, Sensing, Vision and Intelligence, Tata McGraw Hill, 2008, 1st Edition.
2. Ghosal A, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006.
3. Stuart Russell and Peter Norvig, Artificial Intelligence A Modern Approach, Pearson, 2014, 3rd Edition.
4. Everett H R, Sensors for Mobile Robots: Theory and Application, A K Peters/CRC Press, 1995.

CS2434 **3-0-0 (3)**

Cloud Data Management

Pre-Requisites: **None**

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 and cloud data management.
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	–	2	2	2	–	2	2	2	2	2	–	1	2
CO-6	–	–	3	–	3	2	2	–	–	2	–	2	2	–	2	2

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

Syllabus:

Introduction: Cloud computing at a glance; Historical developments; Building cloud computing environments

Principles of Parallel and Distributed Computing: Eras of computing; Parallel vs. distributed computing; Elements of parallel computing; Elements of distributed computing; Technologies for distributed computing

Virtualization: Introduction; Characteristics of virtualized environments; Taxonomy of virtualization techniques; Virtualization and cloud computing; Pros and cons of virtualization; Technology examples

Cloud Computing Architecture: Introduction; The cloud reference model; Types of clouds; Economics of cloud; Open challenges

Cloud Platforms in Industry: Amazon web services; Google AppEngine; Microsoft Azure

Cloud Applications: Scientific applications; business and consumer applications

Cloud Data Management: Cloud-hosted data storage systems; Database replication of NoSQL database-as-a-service; Replicating virtualized database servers; SLA-driven database replication on virtualized database servers; Big data processing systems

Advanced Topics in Cloud Computing: Energy efficiency in clouds; 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, Christian Vecchiola and S. Thamarai Selvi, Mastering Cloud Computing: Foundations and Applications Programming, Morgan Kaufmann, 2013
2. Liang Zhao, Sherif Sakr, Anna Liu and Athman Bouguettaya, Cloud Data Management, Springer, 2014

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.

CS2436 **3-0-0 (3)**

Computational Neuro Science

Pre-Requisites: **None**

Course Outcomes:

CO-1	Simulate simple models of neurons, and their populations using computing languages.
CO-2	Understand the working of neural networks to store and process information
CO-3	Construct computational models for hypothesis testing
CO-4	Perform literature surveys and evaluate evidence for the impact of neuroscience on specific computational and cognitive neuroscience theories.

Course Articulation Matrix:

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

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

Syllabus:

Analyzing And Modeling Neural Responses: Introduction-Properties of Neurons, Recording Neuronal Responses, From Stimulus to Response Spike Trains and Firing Rates-Measuring Firing Rates, Tuning Curves, Spike-Count Variability What Makes a Neuron Fire?-Describing the Stimulus, The Spike-Triggered Average, White-Noise Stimuli, Multiple-Spike-Triggered Averages and Spike-Triggered correlations, Spike Train Statistics-The Homogeneous Poisson Process, The Spike-Train Autocorrelation Function, The Inhomogeneous Poisson Process, The Poisson Spike Generator, Comparison with Data, The Neural Code-Independent-Spike, Independent Neuron and Correlation Codes, Temporal Codes

Information Theory: Entropy and Mutual Information, Entropy, Mutual Information, Entropy and Mutual Information for Continuous Variables Information and Entropy Maximization-Entropy Maximization for a Single Neuron, Populations of Neurons, The Whitening Filter, Filtering Input Noise, Temporal Processing in the LGN, Cortical Coding Entropy and Information for Spike Trains

Modeling Neurons And Networks: Levels of Neuron Modeling-Levels of Neuron Modeling, Single-Compartment Models-Integrate-and-Fire Models, Spike-Rate Adaptation and Refractoriness, Hodgkin-Huxley model, Firing-rate Models- Feed forward Networks-Neural Coordinate Transformations, Recurrent Networks, Network Stability, Associative Memory, Excitatory-Inhibitory Networks-Homogeneous Excitatory and Inhibitory Populations, Phase Plane Methods and Stability Analysis, The Olfactory Bulb, Oscillatory Amplification, Stochastic Networks

Plasticity and Learning: Synaptic Plasticity Rules-The Basic Hebb Rule, the Covariance Rule, the BCM Rule, Synaptic Normalization, Subtractive Normalization, Multiplicative Normalization and the Oja Rule, Timing-Based Rules, Unsupervised Learning, Supervised Learning Supervised Hebbian Learning, Classification and the Perceptron, Function Approximation Supervised Error-Correcting Rules, the Perceptron Learning Rule, the Delta Rule-Contrastive Hebbian Learning.

Learning Resources:

Text Books:

1. Peter Dayan and L F Abbott, Theoretical Neuroscience, MIT Press, 2001.
2. Christopher Koeli, Electrophysics of Neuron, MIT Press, 2004, 1st Edition

Reference Books:

1. Computational Neuroscience: A Comprehensive Approach, Chapman and Hall, 2020, 3rd edition.
2. Wulfram Gerstner, Werner M. Kistler, Richard Naud and Liam Paninski, Neuronal Dynamics From single neurons to networks and models of cognition, Cambridge University Press, 1st edition.

Other Suggested Readings:

1. NPTEL Course: BT6270-Introduction to Computational Neuroscience by Prof. V Srinivasa Chakravarthy, IIT Madras.

CS2438 **3-0-0 (3)**

Cyber Physical Systems

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the various platform aspects of cyber physical systems.
CO-2	Understand various modeling formalisms for CPS, such as hybrid automata, state-space methods, etc.
CO-3	Understand CPS security and safety aspects.
CO-4	Understand the basics of CPS implementation.

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

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

Syllabus:

Cyber-Physical Systems Overview: Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications, Building Automation, Medical CPS, CPS – Platform- CPS HW platforms – Processors, Sensors, Actuators – CPS Network – Wireless Hart, CAN, Automotive Ethernet- CPS Sw stack – RTOS – Scheduling Real Time control tasks.

Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques, Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise.CPS implementation issues, From features to automotive software components, Mapping software components to ECUs, CPS Performance Analysis – effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion, Building real-time networks for CPS.

Intelligent CPS, Safe Reinforcement Learning, Robot motion control, Autonomous Vehicle control, Gaussian Process Learning, Smart Grid Demand Response, Building Automation. Secure Deployment of CPS, Secure Task mapping and Partitioning, State estimation for attack detection, Automotive Case study : Vehicle ABS hacking, Power Distribution Case study : Attacks on Smart Grids.

Learning Resources:

Text Books:

1. Rajeev Alur “Principles of Cyber-Physical Systems”, MIT Press, 2015.
2. E. A. Lee, SanjitSeshia “Introduction to Embedded Systems – A Cyber–Physical Systems Approach”, MIT Press, 2013.

CS2440 **3-0-0(3)**

Federated Machine Learning

Pre-requisites: CS2204

Course Outcomes:

CO1	Understand popular methods used in federated machine learning
CO2	Enhance analytical skills by employing federated machine learning
CO3	Develop skills to leverage related technologies like differential privacy and are able to use them within typical federated settings
CO4	Construct a simple federated system and make it scalable

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Federated Learning: Categories of Federated Learning, Distributed Machine Learning, Large-Scale Machine Learning, FL technologies and architectures algorithms, Data distributions, aggregation, Variations of Federated Aggregation, Secure Aggregation, Decentralized Optimization, Statistical and Systems Heterogeneity, Extensions to Federated Analytics.

Differential Privacy within Federated Systems, Privacy-Preserving Distributed Machine Learning, Privacy-Preserving Decision Trees, Privacy-Preserving Techniques, Privacy-Preserving DML Schemes, Privacy-Preserving Gradient Descent, PPML and Secure ML, Threat and Security Models, Privacy Threat Models, Adversary and Security Models.

Horizontal and Vertical Federated Learning: Architecture of HFL and VFL, The Client- Server Architecture, The Peer-to-Peer Architecture, Global Model Evaluation, The Federated Averaging Algorithm, Federated Optimization, The FedAvg Algorithm, The Secured FedAvg Algorithm, Improvement of the FedAvg Algorithm, Communication Efficiency, Client Selection Vertical Federated Learning, Architecture of VFL, Algorithms of VFL, Secure Federated Linear Regression, Secure Federated Tree-Boosting.

Federated Transfer Learning: Heterogeneous Federated Learning, Federated Transfer Learning, The FTL Framework, Federated Reinforcement Learning, Distributed Reinforcement Learning, Asynchronous Distributed Reinforcement Learning, Synchronous Distributed Reinforcement Learning.

Applications to Speech, Video, Images and Robotics- Federated Learning for Vision, Language, and Recommendation: Federated Learning for Computer Vision, Federated CV, Federated Learning for NLP, Federated NLP, Federated Learning for Recommendation Systems, Recommendation Model, Federated Recommendation System.

Learning Resources:

Text Books/Reference Books/Online Resources:

1. Federated Learning (Synthesis Lectures on Artificial Intelligence and Machine Learning), Qiang Yang, Yang Liu, Yong Cheng, Yan Kang, Tianjian Chen, and Han Yu - 2019.
2. Federated Learning Fundamentals and Advances, Yaochu Jin , Hangyu Zhu , Jinjin Xu , Yang Chen, Springer, 2023.

CS2442 **3-0-0 (3)**

Game Theory and Strategy

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

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

Syllabus:

Noncooperative Game Theory: Games in Normal Form - Preferences and utility, examples of normal-form, Analyzing games: Pareto optimality, Nash equilibrium, Maxmin and minmax 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 maxmin and minmax 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

CoalitionalGameTheory: Transferable Utility, Analyzing Coalitional Games, Shapley Value, the Core

Mechanism Design: Strategic voting, unrestricted preferences, Implementation, quasilinear setting, efficient mechanisms, and 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. Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani, “Algorithmic Game Theory”, Cambridge University Press, 2007, First Edition.
2. Ronald Cohn Jesse Russell, Algorithmic Game Theory, VSD Publishers, 2012, First Edition.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc22_cs116/preview
2. https://ocw.mit.edu/courses/14-126-game-theory-spring-2016/

CS2444 **3-0-0 (3)**

Human Computer Interaction

Pre-Requisites: None

Course Outcomes:

CO-1	Understand usability and the factors affecting universal usability.
CO-2	Apply the principles of design process in human computer interaction.
CO-3	Analyze and evaluate the interaction styles in human computer interaction.
CO-4	Analyze the design issues in human computer interaction.
CO-5	Create an interface based on the concepts of human computer interaction.

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction: Usability of Interactive Systems, Universal Usability, Guidelines, Principles, and Theories

Design Processes: Design, Evaluation and the User Experience, Design Case Studies

Interaction Styles: Direct Manipulation and Immersive Environments, Fluid Navigation, Expressive Human and Command Languages, Devices

Design Issues: Advancing the User Experience, The Timely User Experience, Documentation and User Support, Information Search, Data Visualization.

Learning Resources:

Text Books:

1. Ben Shneiderman, Catherine Plaisant, Maxine Cohen, Steven Jacobs, Niklas Elmqvist, Nicholas Diakopoulos, Designing the User Interface: Strategies for Effective Human Computer Interaction, Pearson, 2021, 6th Edition

Reference Books:

1. Wilbert O Galitz, The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques, Wiley, 2007, 3rd Edition

CS2446 **3-0-0 (3)**

Large Language Models

Pre-requisites: **CS2302**

Course Outcomes:

CO-1	Understand the transformers and attention methods.
CO-2	Understanding the concept of pretraining and fine-tuning language models.
CO-3	Design a vanilla attention mechanism for long range context windows.
CO-4	Build a different type of fine-tuning techniques to fine-tune large language models.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Transformers: Introduction to transformers - Self-attention - cross- attention-Masked attention-Positional encoding, A deep dive into number of parameters, computational complexity and FLOPs- Introduction to language modelling, Causal Language Modeling: What is a language model?- Generative Pretrained Transformers (GPT) - Training and inference, Masked Language Modeling : Bidirectional Encoder Representations of Transformers (BERT) - Fine-tuning - A deep dive into tokenization: BPE, SentencePiece, wordpiece, Bigger Picture: T5, A deep dive into text-to-text (genesis of prompting), taxonomy of models, road ahead, Data: Datasets, Pipelines, effectiveness of clean data, Architecture: Types of attention, positional encoding (PE) techniques, scaling techniques, Training: Revisiting optimizers, LION vs Adam, Loss functions, Learning schedules, Gradient Clipping, typical failures during training, Fine Tuning: Prompt Tuning, Multi-task Fine-tuning, Parametric Efficient Fine-Tuning, Instruction fine-tuning datasets, Benchmarks: MMLU, BigBench, HELM, OpenLLM, Evaluation Frameworks, Training Large Models: Mixed precision training,Activation checkpointing, 3D parallelism, ZERO, Bloom as a case study, Scaling Laws: Chinc,hilla, Gopher, Palm v2.

Learning Resources:

Text Books:

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press.
2. Zakaria Sabti, Prompt Engineering Demystified: Unleashing the Power of Large Language Models.

Reference Books:

1. Andrew Radford, “Transformational Grammar: A First Course.”
2. Stephen Wolfram, “What is ChatGPT Doing … and Why Does It Work?”
3. https://stanford-cs324.github.io/winter2022/lectures/

CS2448 **3-0-0 (3)**

Reinforcement Learning

Pre-Requisites: **CS2204, CS2205**

Course Outcomes:

CO-1	Understand elements of RL and solutions to Multi-Arm Bandit Problem.
CO-2	Formulate and solve problems modelled with Markov Reward Process.
CO-3	Comprehend solutions for problems with Markov Decision Process.
CO-4	Apply Dynamic Programming for Markov Decision Process
CO-5	Analyze Temporal 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	1	1	3	3	1	1	1	–	–	–	1	1	3	3	1	–
CO-2	1	2	3	3	1	1	1	–	–	–	1	1	3	3	1	–
CO-3	1	2	3	3	1	1	1	–	–	–	1	1	3	3	1	–
CO-4	-	2	3	3	1	1	1	–	–	–	1	1	3	3	1	–
CO-5	-	1	3	3	1	1	1	–	–	–	1	1	3	3	1	–

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

Syllabus:

Introduction: Introduction to Reinforcement Learning (RL) – Difference between RL and Supervised Learning, RL and Unsupervised Learning. Elements of RL, Markov property, Markov chains, Markov reward process (MRP). Evaluative Feedback - Multi-Arm Bandit Problem: An n-Armed Bandit Problem, Exploration vs Exploitation principles, Action value methods, Incremental Implementation, tracking a non-stationary problem, optimistic initial values, upper-confidence-bound action selection, Gradient Bandits. Introduction to and proof of Bellman equations for MRPs. Introduction to Markov decision process (MDP), state and action value functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations. Dynamic Programming (DP): Overview of dynamic programming for MDP, principle of optimality, Policy Evaluation, Policy Improvement, policy iteration, value iteration, asynchronous DP, Generalized Policy Iteration. Monte Carlo Methods for Prediction and Control: Overview of Monte Carlo methods for model free RL, Monte Carlo Prediction, Monte Carlo estimation of action values, Monto Carlo Control, On policy and off policy learning, Importance sampling. Temporal Difference Methods: TD Prediction, Optimality of TD (0), TD Control methods - SARSA, QLearning and their variants.

Learning Resources:

Text Books:

1. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press 2020/Bradford Books 2018, Second Edition.

Reference Books:

1. Csaba Szepesvari, Algorithms for Reinforcement Learning, Morgan & Claypool, 2010, First Edition.
2. Warren B. Powell, Reinforcement Learning and Stochastic Optimization: A Unified Framework for Sequential Decisions, Wiley, 2022, First Edition.

CS2450 **3-0-0 (3)**

Security and Privacy for Online Social Media

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand fundamentals of social networks.
CO-2	Analyze privacy threats and defense mechanisms in online social networks.
CO-3	Implement user-managed access control models.
CO-4	Apply privacy policies and semantic access control in social networks.
CO-5	Address security and privacy challenges in mobile and P2P 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	2	2	1	2	2	-	-	-	1	2	-	-	2	2	2	1
CO-2	2	3	2	1		-	-	-	-	-	-	-	1	1	2	3
CO-3	1	2	-	-	3	-	-	-	-	-	-	-	2	1	1	1
CO-4	2	1	2	-	-	-	-	-	-	-	-	-	1	-	1	3
CO-5	2	2	2	2	-	-	-	-	-	-	-	-	1	-	1	3

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

Syllabus:

Introduction to Online Social Networks: Fundamental concepts of social networks, Common representations of social networks, Motivations for social network usage, Privacy attacks using social network analysis and link mining.

Online Social Networks: Privacy Threats and Defenses: Threats to users privacy, Defense mechanisms, Usable privacy, Rational privacy vulnerability scanning**.**

User-Managed Access Control in Web-Based Social Networks: Requirements for user-managed access control in WBSNs, SoNeUCONABC access control model, Implementation mechanisms+.

A Flexible User Privacy Policy for Social Networking Services: UPP+ privacy policy model, Formalization using Alloy language, Consistency checking using Alloy analyzer.

Social Semantic Network-based Access Control: Integrating social networks with semantic models, Benefits of semantic access control, Semantic Web languages for access control.

Supporting Data Privacy in P2P Systems: Data privacy in P2P systems, Extension of HDB approach, Solutions for data privacy in P2P systems.

Privacy-Preserving Reputation Management in Social Networks: Privacy-preserving reputation management, Challenges in decentralized social networks, Techniques for preserving privacy.

Security and Privacy Issues in Mobile Social Networks: Challenges in MSNs, Privacy issues with contextual information, Solutions for privacy and security in MSNs.

Learning Resources:

Text Books:

1. Yaniv Altshuler, Yuval Elovici, Armin B. Cremers, Nadav Aharony and Alex Pentland, Security and Privacy in Social Networks, doi.org/10.1007/978-1-4614-4139-7, Springer, New York, NY
2. Springer New York, NYHacking Web Apps Detecting and Preventing Web Application Security Problems, Mike Shema, Syngress publications- Elsevier
3. Patrick Van Eecke, Maarten Truyens, Privacy and social networks, Computer Law & Security Review;2010; 26(5):535-546.

CS2452 **3-0-0(3)**

Semantic Web

Pre-requisites: CS1106

Course Outcomes:

CO1	Understand the standards and data formats used in the Semantic Web.
CO2	Comprehend technologies including XML and XSLT.
CO3	Design semantic web meta data and RDF schema.
CO4	Develop ontology programming with Jena API.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	-	-	-	1	-	-	2	-	2	-	-	-	-	1	1
CO2	-	1	2	-	2	1	2	-	-	-	-	2	-	1	2	1
CO3	2	1	1	1	2	1	-	1	2	1	2	1	1	1	2	1
CO4	-	-	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 / Reference Books / Online Resources:

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.

CS2454 **3-0-0(3)**

Social Networks

Pre-requisites: **CS1106, CS2323**

Course Outcomes:

CO1	Understand the importance of social networks and social graphs.
CO2	Enhance analytical skills for analyzing social networking data.
CO3	Develop skills to leverage extended enterprise data.
CO4	Create real-life case studies using social networks.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to social network analysis: Graphs – nodes, edges, direct and indirect friends/neighbors, degree and degree distribution, shortest path, cycle, tree, complete graph, bipartite graphs, directed graphs, weighted graphs, adjacency matrix, social interactions and connected components. Technological networks (internet, telephone network, power grids, transportation networks), social networks (facebook, movie collaboration, paper collaboration), information networks (web), biological networks (neural networks, ecological networks).

Network Centrality Measures and Models: Properties of real-world network – degree distribution, clustering coefficient, average path length; Random Graphs – Evolution of random graphs, properties of random graphs, modeling real-world networks with random graphs, Erdos-Renyi model of random graph; Small-world Model – Properties of the Small-world model, modeling real-world networks with the small-world model; Preferential attachment model – Properties of the preferential attachment model, modeling real-world networks with the preferential attachment model.

Random walk-based proximity measures, other graph-based proximity measures. Clustering with random-walk based measures.

Influence and Homophily: Measuring Assortativity, Measuring and modeling Influence, Measuring and modeling Homophily, Distinguishing influence and homophily – shuffle test, edge-reversal test, randomization test; Spread of influence through a network, influence maximization in networks, spread of disease on networks.

Games on networks, game theory strategies, dominant strategies, dominated strategies, pure strategies and mixed strategies, Nash equilibrium, multiple equilibria-coordination games, multiple equilibria-the Hawk-Dove game, mixed strategies, modeling social network traffic using game theory.

Learning Resources:

Text Books:

1. Reza Zafarani, Mohammad Ali Abbasi, Huan Liu, "Social Media Mining – An Introduction", Cambridge University Press, 2014.
2. David Easley and Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010.
3. Mark Newman, Networks: An Introduction, Oxford University Press, 2010.

Reference Books:

1. Hansen, Derek, Ben Sheiderman, Marc Smith, Analyzing Social Media Networks with NodeXL: Insights from a Connected World, Morgan Kaufmann, 2011.
2. Avinash Kaushik, Web Analytics 2.0: The Art of Online Accountability, Sybex, 2009.

CS2456 **3-0-0 (3)**

Video Analytics

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply the basics of image processing for computer vision task
CO-2	Design an object detection approach
CO-3	Design face recognition and gesture recognition algorithms
CO-4	Apply Video Processing methods
CO-5	Apply principles of video Analytics to solve a real-world engineering problem

Course Articulation Matrix:

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

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

Syllabus:

Introduction: Computer Vision; Image representation and image analysis tasks; Image representations; digitization; properties; color images; Data structures for Image Analysis; Levels of image data representation; Traditional and Hierarchical image data structures;

Image Pre-Processing: Local pre-processing; Image smoothing; Edge detectors; Zero-crossings of the second derivative; Scale in image processing; Canny edge detection; Parametric edge models; Local pre-processing in the frequency domain; Line detection by local pre-processing operators; Image restoration

Object Detection Using Machine Learning: Object detection; Object detection methods; Deep Learning framework for Object detection; bounding box approach; Intersection over Union (IoU); Deep Learning Architectures: R-CNN, Faster-R-CNN, You Only Look Once (YOLO); Salient features; Loss Functions; YOLO architectures

Face Recognition And Gesture Recognition: Face Recognition; Introduction; Applications of Face Recognition; Process of Face Recognition; Deep Face solution by Facebook; FaceNet for Face Recognition; Implementation using FaceNet; Gesture Recognition;

Video Analytics: Video Processing; use cases of video analytics; Vanishing Gradient and exploding gradient problem; RestNet architecture; RestNet and skip connections; Inception Network; GoogleNet architecture; Improvement in Inception v2; Video analytics; RestNet and Inception v3.

Learning Resources:

Text Books:

1. Milan Sonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis, and Machine Vision, Thomson Learning, 2013
2. Vaibhav Verdhan, Computer Vision Using Deep Learning Neural Network Architectures with Python and Keras, Apress, 2021

Reference Books:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2022, 2nd Edition
2. Caifeng Shan, Fatih Porikli, Tao Xiang, Shaogang Gong, Video Analytics for Business Intelligence, Springer, 2016
3. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, Pearson, 2015, 2nd Edition
4. E. R. Davies, Computer Vision: Principles, Algorithms, Applications, Learning, Academic Press, 2017, 5th Edition
5. Alan C. Bovik, The Essential Guide to Video Processing, Academic Press, 2009, 2nd Edition
6. Alan C. Bovik, Handbook of Image and Video Processing, Academic Press, 2000
7. A. Murat Tekalp, Digital Video Processing, Pearson, 2015, 2nd Edition

CS2458 **3-0-0 (3)**

Virtual Reality and Augmented Reality

Pre-Requisites: **None**

Course Outcomes:

CO-1	Apply concepts of Virtual Reality.
CO-2	Apply concepts of Augmented Reality.
CO-3	Integrate sensors with AR/VR system.
CO-4	Design AR/VR application for a given task.
CO-5	Analyze existing AR/VR 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	2	2	–	–	–	–	–	–	–	1	1	–	–
CO-2	2	2	2	2	2	–	–	–	–	–	–	–	1	1	–	–
CO-3	2	2	2	1	2	–	–	–	–	–	–	–	–	2	–	–
CO-4	3	2	2	3	3	–	–	–	–	1	–	–	2	2	2	2
CO-5	2	3	–	3	–	–	–	–	–	–	–	–	–	–	2	2

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

Syllabus:

Introduction to Virtual Reality: Basics, History, Overview of Various Realities, Immersion.

Perception: Objective & Subjective Reality, Perceptual Modalities, Perception of Space & Time.

Content Creation: Environmental design, Affecting Behavior.

Interaction: VR Interaction Concepts, Input Devices, Interaction Patterns & Techniques.

Iterative Design of VR: Philosophy of Iterative Design, The Define stage, Make stage and Learn stage.

Software Development for Virtual Reality

Introduction to Augmented Reality: Basics, Displays, Tracking, Computer Vision for Augmented Reality, Calibration & Registration, Visualization, Interaction, Modeling & Annotation, Authoring, Navigation, Collaboration.

Software Development for Augmented Reality

Application and Future of VR/AR: Applications of VR/AR in Entertainment, Medical, Manufacturing, Education, etc.

Learning Resources:

Text Books:

1. Jason Jerald, The VR Book: Human-Centered Design for Virtual Reality, ACM and Morgan & Claypool Publishers, 2016, 1st Edition.
2. Dieter Schmalstieg, Tobias Hollerer, Augmented Reality, Principles and Practice, Addison Wesley, 2016, 1st Edition.
3. Ralf Doerner, Wolfgang Broll, Paul Grimm, Bernhard Jung, Virtual and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR), Springer, 2022.

Reference Books:

1. Steven M. LaValle, Virtual Reality, Cambridge University Press, 2023.
2. Jesse Glover and Jonathan Linowes, Complete Virtual Reality and Augmented Reality Development with Unity, Packt Publishers, 2019.

SYLLABI

Honors: Computer Science and Engineering (Artificial Intelligence & Data Science)

CS2H01 **3-0-0 (3)**

Multi Agent Systems

Pre-requisites: **CS1106, CS2202**

Course Outcomes:

CO-1	Understand the notion of an agent, how agents are distinct from other software paradigms and characteristics of applications.
CO-2	Understand the key issues associated with constructing agents capable of intelligent autonomous action, and the main approaches taken to developing such agents.
CO-3	Understand the key issues in designing societies of agents that can effectively cooperate in order to solve problems, including an understanding of the key types of multi-agent interactions possible in such systems.
CO-4	Understand the main application areas of agent-based solutions, and be able to develop a meaningful agent-based system using a contemporary agent development platform.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: agents and objects, agents and expert systems, agents and distributed systems, typical application areas for agent systems. Intelligent Agents: the design of intelligent agents - reasoning agents, agents as reactive systems; hybrid agents; layered agents (eg Interrap) a contemporary framework for programming agents. Multi-Agent Systems: Classifying multi-agent interactions - cooperative versus non-cooperative; zero-sum and other interactions; what is cooperation? how cooperation occurs - the Prisoner's dilemma and Axelrod's experiments; Interactions between self-interested agents: auctions & voting systems: negotiation; Interactions between benevolent agents: cooperative distributed problem solving (CDPS), partial global planning; coherence and coordination; Interaction languages and protocols: speech acts, KQML/KIF, the FIPA framework. game theory: including normal form and extensive form games, communication: including speech acts, Auctions for multiagent resource allocation; social choice.

Learning Resources:

Text Books:

1. Michael Wooldridge, An Introduction to MultiAgent Systems, Second Edition, Wiley, 2009.
2. Rafael H. Bordini, Jomi Fred Hubner and Michael Wooldridge, Programming Multi-agent Systems in AgentSpeak Using Jason, Wiley, 2007.
3. Y. Shoham and K Layton-Brown, Multiagent Systems – Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge, 2008.
4. D. Fudenberg and Tirole, Game Theory, MIT Press, 1991.
5. V. Krishna, Auction Theory, Second Edition, Elsevier, 2009.

CS2H02 **3-0-0(3)**

Responsible and Explainable Artificial Intelligence

Pre-requisites: **CS2204**

Course Outcomes:

CO1	Understand the fairness of the AI model and explore bias reduction strategy
CO2	Enhance analytical skills in identifying data factors that affect AI algorithms' performance
CO3	Develop skills to leverage trust and fairness in building AI systems
CO4	Create real-life case studies for Responsible AI frameworks in different scenarios

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Explainable and Responsible AI, Robustness, Need for Ethics in AI. AI for Society and Humanity, Stages of AI model development and how XRAI is relevant to these stages, Responsible AI Frameworks; Bias and Fairness of AI Model - Fairness and Bias - Sources of Biases, Exploratory data analysis, limitation of a dataset, Preprocessing, in-processing and postprocessing to remove bias, Group fairness and Individual fairness, Counterfactual fairness; Explainable AI- Interpretability through simplification and visualization, Intrinsic interpretable methods, Post Hoc interpretability, Explainability through causality, Model agnostic Interpretation; Ethical Considerations in AI, Ethics, and Accountability - Auditing AI models, fairness assessment, Principles for ethical practices; Vulnerability of AI Model, Privacy preservation - Attack models, Privacy-preserving Learning, Differential privacy, Federated learning; Case studies - Recommendation systems, Computer Vision, Natural Language Processing, etc.; Responsible Generative AI and Large Language Models.

Learning Resources:

Text Books:

1. Virginia Dignum, “Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way” Springer Nature, 2019.
2. Christoph Molnar “Interpretable Machine Learning”.Lulu, 1st Edition, 2019.

Advanced Topics in Data Mining

Pre-Requisites: **None**

Course Outcomes:

CO-1	Analyze Algorithms for sequential patterns.
CO-2	Determine patterns from time series data.
CO-3	Develop algorithms for Temporal Patterns.
CO-4	Apply Graph mining algorithms to Web Mining.
CO-5	Compare and contrast distributed algorithms for data mining tasks.

Course Articulation Matrix:

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

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

Syllabus:

Sequential Pattern Mining concepts, primitives, scalable methods; Transactional Patterns and other temporal based frequent patterns, Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis; Graph Mining, Mining frequent subgraphs, finding clusters in large graphs; Web Mining, Mining the web page layout structure, mining web link structure, Automatic classification of web documents and web usage mining; Distributed Data Mining, Distribute data mining framework, Distributed data source, Distributed data mining techniques, Distributed classifier learning, distributed clustering, distributed association rule mining.

Learning Resources:

Text Books:

1. Jiawei Han and M Kamber, Data Mining Concepts and techniques, Morgan Kaufmann Publishers In, 2022; Fourth Edition.
2. Chris Chatfield, The Analysis of Time Series: An Introduction, Chapman & Hall/CRC, 2003, Sixth Edition.

Reference Books:

1. Bing Liu, Web Data Mining, Springer, 2011, Second Edition.
2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne and Vipin Kumar, Introduction to Data Mining, Pearson, 2018, Second Edition.

CS2H05 **3-0-0 (3)**

Deep Reinforcement Learning

Pre-requisites: CS2205, CS2302

Course Outcomes:

CO-1	Understand reinforcement and Q-Learning algorithm.
CO-2	Design Q-Learning to deal with large state spaces.
CO-3	Design Policy based and values-based methods.
CO-4	Build Actor-Critic methods, Approximate Q-Learning and the wire-fitting 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	2	1	1	2	2	–	1	–	–	1	–	–	2	1	2	2
CO-2	2	1	2	2	2	–	1	–	–	1	–	–	2	2	2	2
CO-3	2	1	1	2	2	–	1	–	–	1	–	–	2	2	2	2
CO-4	2	2	2	2	2	1	2	–	–	1	1	–	2	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Optimal Control and Dynamic Programming: Dynamic systems, optimal control, and Markov Decision Processes, Modeling, simulation, and system identification, Formal solution methods and limitations, Dynamic programming, Limitations of model-based control; Introduction to Reinforcement Learning: The basic Q-Learning algorithm, Exploration-exploitation trade-off, short-term long-term reward, Generalizability of reinforcement systems, Challenges in scaling Q-Learning to large state spaces; Deep Feedforward Networks: Linear and nonlinear supervised learning, Simple recipes for building deep feedforward networks, First order optimization, Useful optimization tricks for deep networks, Convolutional networks; Reinforcement Learning in large state spaces: Extending Q-Learning to deal with large state spaces, The limits of discretization, Q-Learning with function approximators, Deep Q-Learning, Performance engineering, Memory replay and optimization; Policy gradient methods: The Q function, basic geometry, and multiclass classification, The policy gradient algorithm, The probabilistic perspective, Performance engineering; Reinforcement in continuous action space: Actor-Critic methods, Approximate Q-Learning and the wire-fitting algorithm, Other popular extensions of Q-Learning.

Learning Resources:

Text Books:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019.
2. Wiering, Marco, and Martijn Van Otterlo. "Reinforcement learning." Adaptation, learning, and optimization 12 (2012): 3.
3. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. "Deep learning." MIT press, 2016.

CS2H07 **3-0-0 (3)**

Generative AI

Pre-requisites: **CS2204**

Course Outcomes:

CO1	Understand the Generative AI models.
CO2	Enhance analytical skills with generative AI capabilities.
CO3	Develop skills to leverage trust and fairness in building Generative AI systems.
CO4	Create real-life case studies for Generative AI frameworks in different scenarios.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Introduction to Generative AI, Overview of generative models and their applications, Importance of Generative AI in various domains; Mathematical and computational foundations of generative modelling; Variational Autoencoders, Language Models and LLM Architectures. GPT (Generative Pre-trained Transformer): Pre-training and fine-tuning processes, Architecture and working of GPT models, Overview of GPT variants, ChatGPT, Improving ChatGPT's performance Topic: Prompt Engineering and Promot Designing, Strategies for designing effective prompts Techniques for controlling model behavior and output quality, OpenAI, LangChain: Simplifying Development with Language Models, LangChain framework and its components, Streamlining application development using LangChain Examples of applications built with LangChain, RAG Models- Embeddings, Indexing networks, vector databases; Generative AI models and tools for text, code, image, audio, and video generation. Text to Image Generative AI, Multimodal Generative AI. Ethical considerations and challenges: Ethical Considerations in Generative AI Understanding the ethical implications of generative models, Addressing bias and fairness in generative AI systems Ensuring responsible use and deployment of generative models, Generative AI Use Cases.

Learning Resources:

Text Books:

I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016.

Online References:

1. Fabian Gloeckle, Badr Youbi Idrissi, Baptiste Roziere, David Lopez-Paz, Gabriel Synnaeve, Better & Faster Large Language Models via Multi-token Prediction, arXiv:2404.19737v1, 30 Apr 2024.
2. A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, Ł. Kaiser, and I. Polosukhin, "Attention Is All You Need," in Proceedings of the Thirty-First Conference on Neural Information Processing Systems (NeurIPS), 2017.

3. N. S. Keskar, B. McCann, L. R. Varshney, C. Xiong, and R. Socher, “CTRL: A Conditional Transformer Language Model for Controllable Generation,” arXiv:1909.05858.
4. K. Lu, A. Grover, P. Abbeel, and I. Mordatch, "Pretrained Transformers as Universal Computation Engines," arXiv:2103.05247, March 2021.
5. L. Reynolds and K. McDonell, "Prompt Programming for Large Language Models: Beyond the Few-Shot Paradigm," Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems, May 2021.
6. B. Lester, R. Al-Rfou, and N. Constant, "The Power of Scale for Parameter-Efficient Prompt Tuning," in Proceedings of the 2021 Conference on Empirical Methods in Natural Language Processing, pp. 3045–3059, Nov. 2021.

CS2H08 **3-0-0 (3)**

Streaming Data Analytics

Pre-Requisites: CS2203, CS2204, CS2206, CS2303

Course Outcomes:

CO-1	Design and implement robust streaming data architectures for real-time data processing.
CO-2	Utilize frameworks such as Apache Spark Streaming and Apache Flink to develop real-time data applications.
CO-3	Integrate and manage messaging systems like Apache Kafka for efficient data ingestion.
CO-4	Perform advanced data analytics and visualization using tools like Grafana and Kibana.
CO-5	Ensure fault tolerance, scalability, and security in streaming data pipelines.

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Fundamentals of streaming data, applications of streaming data, batch processing vs. stream processing, components of streaming data architectures, data ingestion, data processing, data storage, Lambda architecture, Kappa architecture, Apache Kafka, RabbitMQ, Amazon Kinesis, Apache Spark Streaming, Apache Flink, real-time data processing techniques, integrating Spark Streaming with Kafka, basic transformations and actions on data streams, stateful stream processing in Flink, storing streaming data in real-time databases, time-series databases (InfluxDB, OpenTSDB), NoSQL databases, real-time data analytics techniques, dashboards for real-time data visualization (Grafana, Kibana), integrating with BI tools, fault tolerance in streaming systems, scaling streaming applications, monitoring and managing streaming data pipelines, real-world use cases, industry applications, security challenges in streaming data, data encryption, access controls, data privacy and compliance, machine learning on streaming data, edge computing, IoT stream processing, capstone project.

Learning Resources:

Text Books:

1. "Streaming Systems: The What, Where, When, and How of Large-Scale Data Processing" by Tyler Akidau, Slava Chernyak, and Reuven Lax
2. "Kafka: The Definitive Guide: Real-Time Data and Stream Processing at Scale" by Neha Narkhede, Gwen Shapira, and Todd Palino
3. Online resources, documentation, and tutorials from Apache Kafka, Apache Spark, and Apache Flink websites.

CS2H10 **3-0-0 (3)**

Web Intelligence & Web Analytics

Pre-Requisites: **CS2203, CS2303**

Course Outcomes:

CO-1	Analyze web traffic and user behavior to gain actionable insights and improve website performance.
CO-2	Set up, configure, and effectively use web analytics tools such as Google Analytics and Adobe Analytics.
CO-3	Implement SEO strategies and measure their impact using analytics tools like Google Search Console and SEMrush.
CO-4	Conduct A/B testing and use content analytics to optimize website content and user experience.
CO-5	Create detailed visualizations and dashboards to communicate web analytics data effectively using tools like Tableau and Google Data Studio.

Course Articulation Matrix:

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

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

Syllabus:

Introduction to web intelligence and web analytics, importance and applications of web analytics, web data collection methods including web scraping and APIs, tools for web scraping such as BeautifulSoup and Scrapy, data cleaning and preprocessing, understanding web traffic and user behavior, key metrics such as page views, sessions, and bounce rate, overview of web analytics tools including Google Analytics and Adobe Analytics, setting up and configuring web analytics tools, advanced features of Google Analytics including tracking user interactions and setting up goals, using Google Tag Manager, basics of Search Engine Optimization (SEO), measuring SEO performance with analytics tools like Google Search Console and SEMrush, content analytics and A/B testing, tools for A/B testing like Optimizely and Google Optimize, social media analytics and tools such as Hootsuite and Socialbakers, key metrics for e-commerce websites, techniques for conversion rate optimization, analyzing and optimizing the customer journey, machine learning in web analytics, predictive analytics for web data, principles of effective data visualization, tools for data visualization like Tableau and Google Data Studio, creating dashboards and reports, data privacy laws and regulations, ethical considerations in web analytics, ensuring compliance and user data protection.

Learning Resources:

Text Books:

1. Avinash Kaushik "Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity", Sybex Publishers, 2009.
2. Brian Clifton, "Advanced Web Metrics with Google Analytics", 3rd Edition, Wiley, 2012.