COIMBATORE INSTITUTE OF TECHNOLOGY

(Government Aided Autonomous Institution Affiliated to Anna University, Chennai)

COIMBATORE - 641 014, TAMILNADU, INDIA

DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

B.TECH. ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Curriculum and Syllabi

(R2021)

Under Choice Based Credit System

(For the students admitted during the academic year 2021 - 2022 and onwards)

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COIMBATORE INSTITUTE OF TECHNOLOGY

(Government Aided Autonomous Institution Affiliated to Anna University, Chennai)

VISION AND MISSION OF THE INSTITUTE

VISION

The Institute strives to inculcate a sound knowledge in Engineering along with realized social responsibilities to enable its students to combat the current and impending challenges faced by our country and to extend their expertise to the global arena.

MISSION

The Mission of the institute is to impart high quality education and training to its students to make them world-class Engineers with a foresight to the changes and problems and pioneers to offer innovative solutions to benefit the nation and the world at large.

DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

VISION AND MISSION OF THE DEPARTMENT

VISION

To promote innovative research and consultancy through effectual teaching and learning process to develop emerging technology solutions for the benefits of industry and society.

MISSION

1. Imparting quality value based technical education and produce technology professionals with innovative thoughts and inspiring leadership skills.
2. Having rational thinking for design and development of cutting-edge products by engaging with industry stakeholders to fulfil the global demands and standards.
3. Strengthening the core competence in the domain of Artificial Intelligence and Data Science
4. Enabling the graduates to adapt to the evolving technologies through strong fundamentals and lifelong learning

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Build next generation of highly skilled graduates equipped with a strong knowledge in Artificial intelligence (AI) and Data Science (DS) for creating innovative solutions to society's pressing challenges.

PEO2: Create engineers in addressing wide variety of challenges in managing and analysing different nature of data and able to use and develop software systems in complex data intensive and AI- related applications.

PEO3: Demonstrate professionalism in graduates and reflect on personal performance and self-management processes as a means of continued professional development and lifelong learning in areas of emerging technologies.

PROGRAM OUTCOMES (POs)

PO1:	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and Artificial Intelligence and Data Science basics to the solution of complex engineering problems.
PO2:	**Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3:	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one‘s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAMME SPECIFIC OUTCOMES (PSO)

1. Graduates should be able to evolve AI based efficient domain specific processes for effective decision making in several domains such as business and governance domains.

2. Graduates should be able to arrive at actionable Fore sight, Insight , hind sight from data for solving business and engineering problems

3. Graduates should be able to create, select and apply the theoretical knowledge of AI and Data Analytics along with practical industrial tools and techniques to manage and solve societal problems

Mapping of POs to PEOs

PROGRAM EDUCATION OUTCOMES (PEOs)	PROGRAM OUTCOMES (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
PEO 1	×	×	×	×	×	×	×		×		×	×
PEO 2	×	×	×	×	×	×			×		×	×
PEO 3	×		×	×		×	×	×	×	×	×	×

Mapping of POs to PSOs

PROGRAM SPECIFIC OUTCOMES (PSOs)	PROGRAM EDUCATION OUTCOMES (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
PSO 1	×	×	×	×	×	×	×		×	×	×	×
PSO 2	×	×	×	×	×	×			×	×	×	×
PSO 3	×	×	×	×	×	×	×	×	×	×	×	×

Mapping of PSOs and PEOs

PROGRAM SPECIFIC OBJECTIVES (PSOs)	PROGRAM EDUCATION OUTCOMES (POs)		
	PEO 1	PEO 2	PEO3
PSO 1	×	×	×
PSO2	×	×	×
PSO3	×	×	×

SUBJECTS OF STUDY
SEMESTER I

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21FYM14	Matrices and Calculus	BS	3	1	0	4
21FYE11	Technical English	HS	2	0	1	2
21FYP13	Engineering Physics	BS	3	0	0	3
21FYC11	Engineering Chemistry	BS	3	0	0	3
21CS11	C Programming	ES	3	0	0	3
21CSL11	C Programming Laboratory	ES	0	0	4	2
21PL11	Physics Laboratory I	BS	0	0	2	0.5
21CL11	Chemistry Laboratory I	BS	0	0	2	0.5
21MEL12	Engineering Practices Laboratory	BS	0	0	2	1
21FYEL11	Employability Skills	EEC	0	0	2	1
Total Credits						**20**

SEMESTER II

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21FYM21	Linear Algebra and Gradient Calculus	BS	3	1	0	4
21AD21	Fundamentals of Industry Revolution 4.0	PC	3	0	0	3
21FYC21	Environmental Science and Engineering	ES	3	0	0	1
21CS21	Digital Design	ES	3	0	0	3
21CSL22	Python Programming	ES	1	0	4	3
21MEL11	Engineering Graphics	ES	1	0	4	3
21PL21	Physics Laboratory II	BS	0	0	2	0.5
21CL21	Chemistry Laboratory II	BS	0	0	2	0.5
21CSL21	Digital Design Laboratory	ES	0	0	2	1
21FYEL21	English for Employability	EEC	0	0	2	1
21CC01	Co-curricular Activities	-	-	-	-	1
	Total Credits					**21**

SEMESTER III

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21AD31	Probability and Statistics	BS	3	1	0	4
21AD32	Data Structures and Algorithms	PC	3	1	0	4
21AD33	Principles of Artificial Intelligence	PC	3	0	0	3
21AD34	Software Engineering Principles and Practices	PC	3	0	0	3
21AD35	Web Development Technologies	PC	3	0	0	3
21AD36	Science of Creativity and Professional Ethics	HS	1	1	0	1
21ADL37	Data Structures and Algorithms Laboratory	PC	0	0	3	1.5
21ADL38	Web Development Laboratory	PC	0	0	3	1.5
21ADOC01	One Credit Course – Elective I	OCC	-	-	-	1
21HOC01	Communication Skills for Engineers – I	EEC	0	0	2	1
Total Credits						**23**

SEMESTER IV

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21AD41	Discrete Mathematics and Automata Theory	BS	3	1	0	4
21AD42	Machine learning techniques	PC	3	0	0	3
21AD43	Database Management Systems	PC	3	0	0	3
21AD44	Principles of Computer Systems	PC	3	0	0	3
21AD45	Data communication and Networking	PC	3	0	0	3
21AD46	Foundation in Data Science	PC	3	0	0	3
21ADL47	Machine Learning Laboratory	PC	0	0	3	1.5
21ADL48	Database Management Systems Laboratory	PC	0	0	3	1.5
21ADOC02	One Credit Course-Elective II	OCC	-	-	-	1
21HOC02	Communication Skills for Engineers – II	EEC	0	0	2	1
Total Credits						**24**

SEMESTER V

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21AD51	Cloud Architecture	PC	3	0	0	3
21AD52	Mobile Application Development	PC	3	0	0	3
21AD53	Data Mining and Analysis	PC	3	0	0	3
21AD54	Big Data Architecture: Tools and Techniques	PC	3	0	0	3
	Professional Elective I	PE	3	0	0	3
	Open Elective I	OE	3	0	0	3
21ADL55	Mobile Application Development Laboratory	PC	0	0	2	1
21ADL56	Data Mining and Analysis Laboratory	PC	0	0	2	1
21ADOC03	Comprehensive Exam Training (One Credit Course)	EEC	-	-	-	1
21AD66	Mini Project *(** Evaluated at Sem VI*)	EEC	0	0	6	-
21ADI57	Internship I * *(To be completed during third/fourth semester vacation)*	EEC	0	0	0	1
Total Credits						**22**

SEMESTER VI

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21AD61	Deep Learning Techniques	PC	3	0	0	3
21AD62	Computer Vision and Pattern Recognition	PC	3	0	0	3
21AD63	Data Visualization	PC	3	0	0	3
	Professional Elective II	PE	3	0	0	3
	Open Elective II	OE	3	0	0	3
21ADL64	Deep Learning Laboratory	PC	0	0	4	2
21ADL65	Data Visualization Laboratory	PC	0	0	2	1
21AD66	Mini Project	EEC	0	0	6	3
21ADI67	Internship II* *(To be completed during fourth/fifth semester vacation)*	EEC	0	0	0	1
Total Credits						**22**

SEMESTER VII

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21AD71	Data Security	PC	3	0	0	3
21AD72	IoT and its Applications	PC	3	0	0	3
21AD73	Applied Natural Language Processing	PC	3	0	0	3
	Professional Elective III	PE	3	0	0	3
	Professional Elective IV	PE	3	0	0	3
21ADL74	Applied Natural Language Processing Laboratory	PC	0	0	2	1
21ADL75	Internet of Things Laboratory	PC	0	0	2	1
21AD76	Project Phase-I	EEC	0	0	6	3
Total Credits						**20**

SEMESTER VIII

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
	Professional Elective – V	PE	3	0	0	3
	Professional Elective – VI	PE	3	0	0	3
21AD81	Project Phase-II	EEC	0	0	10	5
	Total Credits					**11**

Note:

- **Open Electives can be opted from other departments too**
- **NPTEL 12-week courses, CISCO certifications, AWS certifications, PM certifications can be opted instead of electives with approval of department**

TOTAL CREDITS:

Semester I and Semester II : 41

Semester III to Semester VIII : 122

Total : 163

PROFESSIONAL ELECTIVES

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE01	User Interface Design	PE	3	0	0	3
21ADE02	Design and Analysis of Algorithms	PE	3	0	0	3
21ADE03	Information Retrieval	PE	3	0	0	3
21ADE04	Generative AI	PE	3	0	0	3
21ADE05	Agile Software Development	PE	3	0	0	3
21ADE06	Optimization Techniques	PE	3	0	0	3
21ADE07	Graph Theory in Data Science	PE	3	0	0	3
21ADE08	Virtual Reality	PE	3	0	0	3
21ADE09	Regression Analysis	PE	3	0	0	3
21ADE10	Software Testing	PE	3	0	0	3
21ADE11	Reinforcement Learning	PE	3	0	0	3
21ADE12	Fundamentals of Blockchain	PE	3	0	0	3
21ADE13	Evolutionary Algorithms	PE	3	0	0	3
21ADE14	Digital Forensics	PE	3	0	0	3
21ADE15	Distributed Systems	PE	3	0	0	3
21ADE16	Cyber-Physical Systems	PE	3	0	0	3
21ADE17	Social Media Analytics	PE	3	0	0	3
21ADE18	DevOps	PE	3	0	0	3
21ADE19	Mining Large Datasets	PE	3	0	0	3

21ADE20	Information Theory and Coding	PE	3	0	0	3
21ADE21	AI in healthcare	PE	3	0	0	3
21ADE22	Financial AI	PE	3	0	0	3
21ADE23	Intelligent Systems	PE	3	0	0	3
21ADE24	Fog Computing	PE	3	0	0	3
21ADE25	Business Analytics	PE	3	0	0	3
21ADE26	Speech Recognition	PE	3	0	0	3
21ADE27	Neural Networks in Cognitive Science	PE	3	0	0	3
21ADE28	Game theory in AI	PE	3	0	0	3
21ADE29	GPU computing	PE	3	0	0	3
21ADE30	Ethical Hacking	PE	3	0	0	3

Professional Electives 1

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE01	User Interface Design	PE	3	0	0	3
21ADE02	Design and Analysis of Algorithms	PE	3	0	0	3
21ADE03	Information Retrieval	PE	3	0	0	3
21ADE04	Generative AI	PE	3	0	0	3
21ADE05	Agile Software Development	PE	3	0	0	3

Professional Electives 2

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE06	Optimization Techniques	PE	3	0	0	3
21ADE07	Graph Theory in Data Science	PE	3	0	0	3
21ADE08	Virtual Reality	PE	3	0	0	3
21ADE09	Regression Analysis	PE	3	0	0	3
21ADE10	Software Testing	PE	3	0	0	3

Professional Electives 3

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE11	Reinforcement Learning	PE	3	0	0	3
21ADE12	Fundamentals of Blockchain	PE	3	0	0	3
21ADE13	Evolutionary Algorithms	PE	3	0	0	3
21ADE14	Digital Forensics	PE	3	0	0	3
21ADE15	Distributed Systems	PE	3	0	0	3

Professional Electives 4

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE16	Cyber-Physical Systems	PE	3	0	0	3
21ADE17	Social Media Analytics	PE	3	0	0	3
21ADE18	DevOps	PE	3	0	0	3
21ADE19	Mining Large Datasets	PE	3	0	0	3
21ADE20	Information Theory and Coding	PE	3	0	0	3

Professional Electives 5

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE21	AI in healthcare	PE	3	0	0	3
21ADE22	Financial AI	PE	3	0	0	3
21ADE23	Intelligent Systems	PE	3	0	0	3
21ADE24	Fog Computing	PE	3	0	0	3
21ADE25	Business Analytics	PE	3	0	0	3

Professional Electives 6

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE26	Speech Recognition	PE	3	0	0	3
21ADE27	Neural Networks in Cognitive Science	PE	3	0	0	3
21ADE28	Game theory in AI	PE	3	0	0	3

21ADE29	GPU computing	PE	3	0	0	3
21ADE30	Ethical Hacking	PE	3	0	0	3

One Credit Course

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
Industry based						
	Advanced Analytics	OCC	-	-	-	1
	Amazon Web Services	OCC	-	-	-	1
	Software Project Management	OCC	-	-	-	1
NPTEL						
	Python for Data Science	OCC	-	-	-	1
	Introduction to Haskell Programming	OCC	-	-	-	1
	Social Networks	OCC	-	-	-	1
Institution						
	Constitution of India	OCC	-	-	-	1
	Biology for Engineers	OCC	-	-	-	1
	Human Values	OCC	-	-	-	1

Department Based						
	R Programming	OCC	-	-	-	1
	Object Oriented Programming in Java	OCC	-	-	-	1
	Tensor Flow	OCC	-	-	-	1

OPEN ELECTIVE COURSES (OEC)

Course Code	Course Name	L	T	P	C	Eligible Branches
21ADOE01	AI Essentials	3	0	0	3	All Branches
21ADOE02	Introduction to Cloud and Virtualization	3	0	0	3	All Branches
21ADOE03	Data analysis using open-source tools	3	0	0	3	All Branches
21ADOE04	Python for Machine Learning and Deep Learning	3	0	0	3	All Branches
21ADOE05	Data Visualization using Power BI	3	0	0	3	All Branches

		Summary of Credit Distribution										
S/NO	Course Category	1	2	3	4	5	6	7	8	Category Wise Credit	AICTE	TEQIP
1	BS	12	5	4	4	0	0	0	0	25	24	25
2	HS	2	0	1	0	0	0	0	0	3	12	12
3	ES	5	11	0	0	0	0	0	0	16	29	24
4	PC	0	3	16	18	14	12	11	0	74	49	57
5	PE	0	0	0	0	3	3	6	6	18	18	15
6	OE	0	0	0	0	3	3	0	0	6	12	12
7	EEC	1	1	1	1	2	4	3	5	18	15	15
8	OCC	0	1	1	1	0	0	0	0	3		
	Sem wise Credit	**20**	**21**	**23**	**24**	**22**	**22**	**20**	**11**	**163**	**159**	**160**

B. Tech. (Hons) AI and DS Major

Eligibility of the Award

- Student should have earned additionally a minimum of 18 credits from a vertical of the same programme.
- Should have passed all the courses in the first attempt.
- Should have earned a minimum CGPA of 7.50

Vertical 1: Robotics

Subject Code	Subject	SCC[#]	Periods			Credits
			L	T	P	
21ADE31	Principles of Robotics	PE	3	0	0	3
21ADE32	Mechanics of Robotics	PE	3	0	0	3
21ADE33	Control of Robotic Systems	PE	3	0	0	3
21ADE34	Machine Learning for Robotics	PE	3	0	0	3
21ADE35	Robot Operating Systems	PE	3	0	0	3
21ADE36	Autonomous Systems	PE	3	0	0	3
Total Credits						**18**
MOOCs Course (Robotics related): 12 weeks durations (3 credits)		**https://nptel.ac.in https://swayam.gov.in/**				**6**

Vertical 2: Machine Learning and Analytics

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE02	Design and Analysis of Algorithms	PE	3	0	0	3
21ADE07	Graph Theory in Data Science	PE	3	0	0	3
21ADE11	Reinforcement Learning	PE	3	0	0	3
21ADE17	Social Media Analytics	PE	3	0	0	3
21ADE25	Business Analytics	PE	3	0	0	3
21ADE27	Neural Networks in Cognitive Science	PE	0	0	3	3
Total Credits						**18**
MOOCs Course (AI DS Related): 12 weeks durations (3 credits)		**https://nptel.ac.in https://swayam.gov.in/**				**6**

Vertical 3: Software Development Practices

Subject Code	Subject	SCC#	Periods			Credits
			L	T	P	
21ADE05	Agile Software Development	PE	3	0	0	3
21ADE10	Software Testing	PE	3	0	0	3
21ADE15	Distributed Systems	PE	3	0	0	3
21ADE18	DevOps	PE	3	0	0	3
21ADE23	Intelligent Systems	PE	3	0	0	3
21ADE26	Speech Recognition	PE	3	0	0	3
Total Credits						**18**
MOOCs Course (AI DS Related): 12 weeks durations (3 credits)		**https://nptel.ac.in https://swayam.gov.in/**				**6**

Vertical 4: Smart Digital Technologies

Subject Code	Subject	SCC[#]	Periods			Credits
			L	T	P	
21ADE04	Generative AI	PE	3	0	0	3
21ADE08	Virtual Reality	PE	3	0	0	3
21ADE12	Fundamentals of Blockchain	PE	3	0	0	3
21ADE16	Cyber-Physical Systems	PE	3	0	0	3
21ADE24	Fog Computing	PE	3	0	0	3
21ADE29	GPU Computing	PE	3	0	0	3
Total Credits						**18**
MOOCs Course (AI DS Related): 12 weeks durations (3 credits)		**https://nptel.ac.in https://swayam.gov.in/**				**6**

Minor : Artificial Intelligence

The student should have earned additionally a minimum of 18 credits from the below vertical

Subject Code	Subject	SCC #	Periods			Credits
			L	T	P	
21ADE37	Basics of Artificial Intelligence	OE	3	0	0	3
21ADE38	Machine Learning Concepts and Applications	OE	3	0	0	3
21ADE39	Deep Learning	OE	3	0	0	3
21ADE40	Statistics for Business Data Analytics	OE	3	0	0	3
21ADE41	Big Data Management for Engineers	OE	3	0	0	3
21ADE42	Building AI Products	OE	2	0	2	3
Total Credits						**18**
MOOCs Course (Robotics related): 12 weeks durations (3 credits)			**SCC#**			

Semester	**I**
Subject Code	**21FYM14**
Subject Title	**Matrices and Calculus**
Duration	One Semester
Total Contact Hours	60 Hours per semester
Pre-Requisite	N/A
Credit Points	4 CP
Learning and Teaching Structure	L T P C 3 1 0 4
Assessment Type	Theory
Course Objective	• Acquire sound knowledge of techniques in the fundamental concepts of matrices and their role in modern mathematics and applied contexts. • Deal with derivatives of functions of several variables that are essential in various branches of engineering. • Inculcate the concepts of integral calculus in appropriate physical problems. • Know the basics of vector calculus for the study of computer science and engineering problems. • Analyze the ordinary differential equations that is imperative for the effective understanding of applications in real life problems.

Course Outcome

CO1: Incorporate suitable methods of eigenvalues of matrices and implement the same for applications in software programs.

CO2: Understand maxima and minima concepts and implement in programming problems.

CO3: Solve multiple integrals and apply to find area and volume of surfaces and solids.

CO4: Provide the strong background of vector calculus for the study of science and technological problems.

CO5: Assimilate the efficient use of ordinary differential equations in software problems.

MATRICES

Eigen values and Eigenvectors of a Real matrix – properties (without proofs) –Cayley – Hamilton Theorem (without proof) – Diagonization by an Orthogonal Transform – Quadratic forms – Transformation of a Quadratic form to canonical form **(9)**

DIFFERENTIAL CALCULUS

Taylor's series for functions of two variables – Maxima and Minima of functions of two variables – Lagrange's method of undetermined multipliers **(9)**

MULTIPLE INTEGRALS

Double integrals – Change of order of integration in double integrals – change of variable (Cartesian to polar) – triple integrals – Applications: Area and Volume **(9)**

VECTOR CALCULUS

Vector Differentiation – Gradient, Divergence and Curl – Directional derivative – Solenoidal and Irrotational vector fields – vector integration – Line, surface and volume integrals – Green's, Stoke's and Gauss divergence theorem (without proof) -simple applications involving cube and rectangular parallelepiped **(9)**

ORDINARY DIFFERENTIAL EQUATIONS

Second and Higher order Linear Differential Equations with constant coefficients, Method of variations and parameters – Cauchy - Euler equations – Cauchy-Legendre Equations – System of simultaneous Linear Differential Equations with constant coefficients. **(9)**

TOTAL: 45 + 15 = 60

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Joel R.Hass, Christopher E.Heil, Maurice D.Weir," Thomos Calculus", 14th Edition, Pearson, 2018.
2. B.V.Ramana, "Higher Engineering Mathematics", Kindle Edition, Tata McGraw Hill, 2018.

Reference Book

1. Grewal.B.S, "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers, 2012.
2. Srimanta pal and Suboth.C.Bhunia, "Engineering Mathematics", Oxford University Press, 2015.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, John Wiley and Sons, 2015.

Semester	**I**
Subject Code	**21FYE11**
Subject Title	**Technical English**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	**N/A**
Credit Points	2 CP
Learning and Teaching Structure	L T P C 2 0 1 2
Assessment Type	Theory
Course Objective	The objective of the course is to strengthen the students' knowledge and use of the English language, and instruct them on how to structure a technical report.

Course Outcome

CO1: Compose appropriate dialogues, construct descriptive paragraphs and review, for a given communication context.

CO2: Categorize the barriers to communication and formulate solutions for a communication context. Generate functional expressions and construct dialogues, for a given situation, like introducing oneself, asking questions, disagreeing, expressing preferences, asking for and giving directions.

CO3: Specify appropriate responses and construct a summary, for a given short conversations and monologues for listening.

CO4: Interpret the given technical graphical representation and compose passages. Summarize and paraphrase technical texts in about 250 to 300 words.

CO5: Apply the rules of the grammar viz., word formation, Verbs, Tenses, Question Tags, Prepositions, Articles, Conjunctions, Concord, Idiomatic Expressions, One Word Substitutes, Homophones and Homonyms, Linking words, adjectives and degrees of comparison, use appropriate patterns in the given sentence.

FOCUS ON LANGUAGE: GRAMMAR & VOCABULARY

Tenses – Question Tags – Prepositions – Articles – Conjunctions – Subject Verb Agreement – Idiomatic Expressions - Word Formation: Prefixes & Suffixes - One Word Substitutes – Homophones and Homonyms – Contracted form of Verbs – Emphasis - Linking Words – Common Errors and Redundancies – Adjectives - Degrees of Comparison **(5)**

TECHNICAL COMMUNICATION

Importance of Technical Communication - Objective & Characteristics of Technical Communication – General and Technical Communication – Process of Communication - Levels of Communication – Flow of Communication –Visual Aids in Technical Communication - Barriers to Communication: Noise – Classification of Barriers –Non-verbal Communication: Kinesics – Proxemics- Chronemics - Social Media Etiquette **(5)**

READING

Reading Comprehension – Skimming and Scanning – Summarizing – Sequencing of Sentences - Intensive & Extensive Reading- Note Making – SQ3R Reading Technique. **(4)**

WRITING

Gadget Review – Types of Paragraphs – Description – Describing Structures – Information Transfer - Describing Trends – Paragraph Construction - Paragraph Patterns – Kinds of Paragraph – Writing a First Draft, Revising & Finalizing - Steps to Effective Précis Writing - Dialogue Writing – Essay Writing **(6)**

LISTENING

Meaning and Art of Listening-Importance of Listening & Empathy in Communication – Reasons for Poor Listening – Traits of a good listener – Listening modes - Listening and Filling Information – Identifying parts from a discussion. **(4)**

SPEAKING

Introducing Oneself- Asking Questions –Retelling an Incident – Small Talk – Disagreeing – Expressing Preferences – Asking for and Giving Directions -Achieving Confidence, Clarity & Fluency – Vocal Cues - Barriers to Speaking – Types of Speaking – Persuasive Speaking – Public Speaking - Effective Presentation Strategies – Planning - Outlining & Structuring – Nuances of Delivery – Controlling Nervousness & Stage Fright – Making an Oral Presentation -Visual Aids in Presentation – Applications of MS Power Point. **(6)**

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Sudharshana N. P &Savitha C, “English for Technical Communication”, CUP, 2016.
2. Meenakshi Raman, Sangeeta Sharma, “Technical Communication – Principles and Practice”, Oxford University Press, New Delhi, 2015.

EXTENSIVE READING

C.M.Sharma, “Twelve Short Stories” OUP, 2000. (Only Essay Questions)

Reference Book

1. Jack C Richerds, “Interchange - 2”, CUP, Fourth Edition, Chennai, 2015.
2. Sudharshana N. P &Savitha C, “English for Engineers”, CUP, 2018
3. Ronald Carter, Michael McCarthy. “Cambridge Grammar of English” Cambridge University Press, 2011.
4. Michael McCarthy and Felicity O’Dell, “English Vocabulary in Use”, Cambridge University Press, 2012.
5. Mark Ibbotson. “Cambridge English for Engineering” Cambridge University Press, 2012.

Semester	**I**
Subject Code	**21FYP13**
Subject Title	**Engineering Physics**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	**N/A**
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To impart knowledge about lasers, optical fibers, quantum mechanics, conductors and dielectric materials and nanomaterials

Course Outcome

CO1: The students will gain knowledge and understanding of lasers and optical fibers

CO2: The students will have a conceptual understanding about quantum mechanics and acquire basic knowledge about nano materials

CO3: The students will be able to demonstrate competency and understanding of the electrical properties of conductors and dielectrics

LASERS

Absorption and emission – Spontaneous emission – Stimulated emission – population inversion – sources of excitation – Active medium – Resonant cavity – Einstein's theory of stimulated emission – Nd-YAG laser –CO_2 laser – Semiconductor laser – Applications – 3D profiling, laser drilling and laser welding **(9)**

FIBER OPTICS

Optical fiber – advantages of optical fiber as wave guide and propagation of light in optical fibers – Numerical aperture and acceptance angle – Structure of optical fiber – fiber optical materials – types of fiber opticals – single and multimode fibers – Step index and graded index fibers – Applications – fiber optic communication system, fiber endoscope **(9)**

QUANTUM MECHANICS

Compton effect – expression of Compton shift – concept of matter waves – physical significance of wave function – Schrodinger's wave equation – time independent and time dependent equation –Eigen values and eigen functions – particle in a box (one dimension)-scanning electron microscope(SEM) – Transmission electron microscope(TEM) **(9)**

CONDUCTING AND DIELECTRIC MATERIALS

Conductors – classical free electron theory of metals – Electrical and thermal conductivity – Wiedemann- Franz law – Lorentz number – drawbacks of classical free electron theory. Electrical susceptibility – dielectric constant – electronic, ionic, orientation and space charge polarization – frequency and temperature dependence of polarization – internal field – Clausius – Mosotti relation(derivation) **(9)**

NANO TECHNOLOGY AND NEW ENGINEERING MATERIALS

Nanomaterials – preparation of nano materials – physical vapour deposition – sol gel method – properties of nano particles – applications – Shape memory alloys – characteristics and applications – Liquid crystal display – Twisted nematic display – metallic glasses – preparation, properties and applications **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. V.Rajendran, "Engineering Physics", Tata McGraw Hill, New Delhi, 2017.
2. Avadhanulu .M.N, Kshirsagar P.G, Arun Murthy T.V.S," A Textbook of Engineering Physics", S.Chand & Company Ltd.,New Delhi, 2018.

Reference Book

1. S.Jayakumar, "Engineering Physics", RK Publishers, Coimbatore, 2007.

Semester	**I**
Subject Code	**21FYC11**
Subject Title	**Engineering Chemistry**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	**N/A**
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To impart a sound knowledge on the principles of chemistry involving the different application oriented topics required for all engineering branches. The students will learn to calculate the calorific values for different fuels. They will understand the sources of energy conversion and storage devices. They will learn the preparation of nano materials of different size and shapes using different synthetic techniques.

Course Outcome

CO1: The students will be able to calculate the calorific value of different types of ules and apply the same for suitable applications

CO2: The students will be conversant with the principles and implication of corrosion and its applications

CO3: The students will be able to familiarize with various types of material analysis

CO4: The students will be able to synthesize the nano materials of different size and shapes using different synthesis technique and apply the same for the energy conversion and storage devices.

FUELS AND COMBUSTION

Classification of fuels – calorific value, unit of heat, Gross and Net calorific values. Determination of calorific value by Bomb calorimeter –Dulong's formula – Theoretical calculation of calorific value. Coal - types of coal –Analysis of coal - Proximate analysis and ultimate analysis – Metallurgical coke – carbonization, manufacture – Otto Hoffmann's by-product oven method. Petroleum: Refining of crude oil, Knocking, octane number and cetane number. LPG – composition – characteristics and advantage. CNG – composition characteristics applications – advantages over LPG **(9)**

CORROSION AND ITS CONTROL

Introduction – mechanism of corrosion – chemical corrosion, electro chemical corrosion – differential aeration corrosion – Pilling Bedworth rule – factors influencing corrosion. Corrosion control – cathodic protection – sacrificial anodic protection method – impressed current cathodic protection – use of inhibitors. Protective coatings – metallic coatings - anodic and cathodic coating – Methods of applications of metal coatings. Organic coatings – paint, varnishes, emulsion paints –special paints, Luminescent paint – Heat – resistant paint, Fire retardant paint – water repellent paint – antifouling point **(9)**

ENGINEERING MATERIALS

Refractories – classification – acidic, basic and neutral refractories – properties [refractoriness, refractoriness under load, dimensional stability, porosity, thermal spalling] – manufacture of Alumina – magnesite and Zirconia bricks. Abrasives – natural and synthetic abrasives – quartz, corundum, emery, garnet, diamond, silicon carbide and boron carbide. Lubricants – mechanism of lubrication, classification of lubricants: liquid lubricants – properties [viscosity index. Flash and fire points, cloud and pour points, oiliness] – solid lubricants – graphite and molybdenum sulphide, semi – solid lubricants. **(9)**

ENERGY SOURCES AND STORAGE DEVICES

Nuclear fission – controlled nuclear fission – nuclear fusion – difference between nuclear fission and nuclear fusion – nuclear chain reactions – nuclear energy – light water nuclear power plant – breeder reactor – solar energy conversion – solar cells – principles and applications of silicon solar cell – wind energy. Batteries, fuel cells and super capacitors : Types of batteries – primary batteries(dry cell) – secondary battery(lead acid battery, lithium-ion-battery) fuel cells- H_2O_2 fuel cells **(9)**

NANO CHEMISTRY

Basics – distinction between molecules, nano particles and bulk materials: size dependent properties. Nano particles: nano cluster, nano rod, nano tube (CNT) and nano wire. Synthesis: precipitation, thermolysis, hydro thermal, solvo thermal, electro deposition, chemical vapour deposition, laser ablation; Nano materials: properties and applications.

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. P.C.Jain and Monica Jain, "Engineering Chemistry", 16th Edition, Dhanpat Rai publishing company, 2015.
2. Shashi Chawla, "A Text book of Engineering Chemistry", Dhanpat Rai company, 2017.

Reference Book

1. S.S Dara and S.S Umare,"A Text book of Engineering Chemistry", 12th Edition, S Chand company, 2004.
2. T.Pradeep,"Nano The Essentials: Understanding Nano science and Nano technology", Tata McGraw-Hill publishing company limited, New Delhi, 2008.

Semester	**I**
Subject Code	**21CS11**
Subject Title	**C Programming**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	**N/A**
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject objective is to cover the concepts of c programming to solve computational problems

Course Outcome

CO1: Fundamental knowledge in problem solving, designing algorithms and representation through flowcharts

CO2: Develop simple programs using decision making statements and looping constructs

CO3: Handling series of data items through arrays and pointers

CO4: Understand and practice modularization of the given problem using functions.

CO5: Ability to solve real-world problems involving collection of data items through structures and files.

INTRODUCTION TO PROGRAMMING

Fundamental of programming – Flowcharts. Programming strategies(introduction) : Top-Down, Structured programming, object oriented programming **(5)**

INTRODUCTION TO C

C Data types – C Compilation and execution – Operators: Hierarchy of operators, associativity of operators- expressions – single dimensional arrays – console I/O functions : formatted I/O: scanf(), printf(), getchar() and putchar() **(5)**

CONTROL STATEMENTS

If statements – if –else statements – nested if statements – ternary operators – while loop , do-while loop, for loop break and continue statements – switch case – goto and statement labels **(8)**

POINTERS AND ARRAYS

Array of pointers – Multidimensional arrays – pointers and strings - standard string library functions: strlen(), strcpy(), strcat(), strstr() and strcmp(). Dynamic memory allocation and deallocation **(9)**

FUNCTIONS

Function declaration and prototypes – parameter passing – recursion – command line arguments – function pointers – passing pointers to functions – passing arrays to functions – passing function to another function. Storage Classes – C pre-processor **(9)**	
STRUCTURES AND FILES	
Definition of structure – Array of structures – pointer to structures – self-referential structures – Union – Bit fields – Typedef – enum datatype. High level file I/O : Text and Binary file processing- Low level file I/O and processing **(9)**	
TOTAL: 45	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Byron S.Gottfried, "Programming with C", 4th Edition, Tata McGraw-Hill, New Delhi, 2018.

Reference Book

2. Brian W.Kernigham and Dennis M.Ritchie, "The C Programming Language", 2nd Edition, Prentice Hall of India, Reprint, 2016.
3. Herbert Schildt, "C: The Complete Reference", 4th Edition, McGraw Hill, 2017.
4. Deistel HM and Deistel PJ, "C:How to program", Prentice Hall of India, 2008.

Semester	**I**
Subject Code	**21CSL11**
Subject Title	**C Programming Laboratory**
Duration	One Semester
Total Contact Hours	60 Hours per semester
Pre-Requisite	**N/A**
Credit Points	2 CP
Learning and Teaching Structure	L T P C 0 0 4 2
Assessment Type	Practicals
Course Objective	The subject aims to read, understand and implement the c programming language for solving problems. It covers on how to write programs for the given problem or algorithms

Course Outcome

CO1: Ability to write, compile and execute C programs

CO2: Develop simple programs using decision making statements and looping constructs

CO3: Practice operations on arrays, strings and pointers

CO4: Practice modularization of the given problem using functions

CO5: Write programs using structures and files.

LIST OF EXPERIMENTS BASED ON THE FOLLOWING CONCEPTS

1. Operators
2. Decision Statements
3. Control Statements
4. Functions
5. Arrays
6. Pointers
7. Strings
8. Structures
9. Macros
10. Files

TOTAL: 60

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Software Required : Turbo C / gcc

Semester	**I**
Subject Code	**21PL11**
Subject Title	**Physics Laboratory - I**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	**N/A**
Credit Points	0.5 CP
Learning and Teaching Structure	L T P C 0 0 2 0.5
Assessment Type	Practicals
Course Objective	To make students to understand basic concepts of properties of matter, light, electricity, magnetism and semiconductors and acquire experimental skills by carrying out experiments

Course Outcome

CO1: Will be able to gain a fundamental understanding of the apparatus used in the experiments and recognize how observation, experiment and theory work together

LIST OF EXPERIMENTS BASED ON THE FOLLOWING CONCEPTS

1. Air Wedge – Thickness of thin wire
2. Torsional Pendulum – rigidity modules
3. Determination of Band gap of a semiconductor
4. Magnetic field along the axis of a current carrying coil
5. Calibration of Voltmeter and Ammeter
6. Figure of merit of Galvanometer
7. Synthesis of nano materials by sol gel method(Demonstration experiment)

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Semester	**I**
Subject Code	**21CL11**
Subject Title	**Chemistry Laboratory - I**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	**N/A**
Credit Points	0.5 CP
Learning and Teaching Structure	L T P C 0 0 2 0.5
Assessment Type	Practicals
Course Objective	• To help the students to understand the principals involved in complexometric titration • To learn the principles such as conductometry and pHmetry • To understand and appreciate the working of conductormeter and pH meter

Course Outcome

CO1: By the estimation of dissolved oxygen present in water, the students will be able to appreciate how oxygen causes corrosion of boiler materials Students can able to handle analytical tools such as conductormeter and pHmeter

CO2: Students will gain an understanding of different types of volumetric titration

LIST OF EXPERIMENTS BASED ON THE FOLLOWING CONCEPTS

11. Estimation of Nickel using Murexide Indicator, by direct method
12. Determination of strength of given HCI using NaOH by pH measurement
13. Assay determination of sodium carbonate
14. Determination of Alkalinity of water by Warden's method
15. Determination of equivalent conductance of a strong electrolyte
16. Estimation of dissolved oxygen in water sample by Winkler's method

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Semester	**I**
Subject Code	**21MEL12**
Subject Title	**Engineering Practices Laboratory**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	**N/A**
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	To provide exposure to the students with hands on experience on various basic engineering practices

Course Outcome

CO1: Understand various engineering practices like carpentry, fitting, sheet metal, plumbing and electrical wiring and relevant tools.

CO2: Identify and rectify minor electrical problems at home and office.

CO3: Implement the skills acquired during their project work

CO4: Develop their hand-eye coordination capabilities.

LIST OF EXPERIMENTS BASED ON THE FOLLOWING CONCEPTS

CARPENTRY

1. Planning and marking practice
2. Chiselling practice
3. Making a half-lap joint
4. Making a dove-tail joint

FITTING

1. Making a square joint
2. Making a dove-tail joint
3. Making a V-joint
4. Making a L and single dove-tail joint

SHEET METAL

1. Making a single seam panned-down joint
2. Making a double seam knocked-up joint
3. Making a dove-tail seam double-grooved joint
4. Fabrication of dust pan
5. Fabrication of rectangular box with base

PLUMBING

1. Practice of external threading
2. Practice of saddle connection to a house service line
3. Study of valve and tap repair
4. Laying of pipe connections for wash basin / sink

ELECTRICAL WIRING

1. BIS Symbols used in electrical circuits and precautions to be observed
2. Preparation of a wiring circuit for a single lamp controlled by a single switch
3. Dim and bright connection method
4. Preparation of wiring circuit to control one lamp by two switches at different places(stair-case wiring)
5. Measurement of power and energy

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Reference Book

1. Engineering Practices Laboratory Manual, Dept. of Mechanical Engineering, CIT, 2019.

Semester	**I**
Subject Code	**21FYEL11**
Subject Title	**Employability Skills**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practical
Course Objective	This course is designed to help students identify the knowledge and skills required for obtaining and keeping employment.

Course Outcome

CO1: Solve timed objective question on logical reasoning and verbal ability.

CO2: Generate ideas and speak confidently, for a given specific speaking task on topics like describing a picture, movie reviews, storytelling, and extempore.

CO3: Use appropriate functional expressions, for a given social situation viz., greeting, thanking, congratulating, apologizing and giving directions.

CO4: Produce language structures accurately and fluently, for a given 2 to5 minutes speaking activity like Extempore and Debate. Prepare a power point presentation for 15 minutes, for a given technical topic.

CO5: Specify appropriate responses and construct a summary for given short conversations and monologues for listening. Construct dialogues for a given social scenario, interpret the given graphic information and write creative paragraphs.

UNIT – 1

Self-Introduction - Barriers to Speaking and Listening – Introduction to Spoken English, Greetings, Thanking - Apologizing, Congratulating - Giving Directions, Shopping – Role Play **(6)**

UNIT – 2

Activity based on newspaper articles - Word Building - A picture and a few words activity - Current Events. **(4)**

UNIT -3

Alphabet test – Alphabet Order, Alphabet Series - Letter Word Problem, Word Formation and Scramble - Series Completion –Para Jumbles- Synonyms and Antonyms- Types and Exercises- Sentence Completion –Types and Exercises. **(8)**

UNIT - 4	
Reading Comprehension- Skimming and Scanning - Reading Prose – Bacon's Essays (Speaking Activity based on the essays) - Story Building- Extempore - Movie Reviews **(4)**	
UNIT – 5	
Speech Sounds - Word Vocabulary - Reading Comprehension - Listening Practice- I - Dialogue Writing - Conversational Exercise – I - Focus on Language - Creative Writing - Conversational Exercise – II - Listening Practice – II **(8)**	
	TOTAL: 30
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.
Text Book **Nil**	
Reference Book **Nil**	

Semester	**II**
Subject Code	**21FYM21**
Subject Title	**Linear Algebra and Gradient Calculus**
Duration	One Semester
Total Contact Hours	60 Hours per semester
Pre-Requisite	N/A
Credit Points	4 CP
Learning and Teaching Structure	L T P C 3 1 0 4
Assessment Type	Theory
Course Objective	The goal of this course is for students to • Acquire sound knowledge of techniques in the fundamental concepts of linear algebra and their role in modern mathematics and applied in various machine learning contexts. • Deal with eigenvalues and eigenvectors that are essential in various branches of engineering. • Inculcate the concepts of Gradient calculus in data analysis. • Know the basics of differentiation and linearization for the study of computer science and engineering problems. • Analyze continues optimization equations that is imperative for the effective understanding of applications in real life problems.

Course Outcome

CO1: Incorporate suitable methods of linear mappings and orthogonal projections and implement the same for applications in machine learning algorithms.

CO2: understand the concepts matrix decompositions and implement in programming problems.

CO3: Gain the ideas of differentiation of univariate functions and gradients of vector valued functions and matrices.

CO4: Provide the strong background of gradient calculus for the study of science and technological problems.

CO5: Assimilate the efficient use of optimization in software problems.

VECTOR SPACES

Vector Spaces - Linear Independence - Basis and Rank- Linear Mappings- Matrix Representation of Linear Mappings- Basis Change. Norms- Inner Products- Lengths and Distances- Angles and Orthogonality - Orthonormal Basis- Orthogonal Complement- Orthogonal Projections (Gram-Schmidt Orthogonalization only) **(10)**

MATRIX DECOMPOSITION

Matrix Decompositions- Determinant and Trace- Eigenvalues and Eigenvectors- Cholesky Decomposition- Singular value Decomposition **(8)**
GRADIENT CALCULUS - I
Differentiation of univariate functions - partial derivatives and gradients - Gradients of vector valued functions and matrices **(9)**
GRADIENT CALCULUS - II
Backpropagation and automatic differentiation - Linearization and Multivariate Taylor Series **(8)**
OPTIMIZATION
Notion of maxima and minima - Optimization using gradient descent - Step-size- Gradient Descent With Momentum- Constrained Optimization and Lagrange Multipliers **(10)**
Theory : 45; Tutorial : 15; **TOTAL: 60**

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. M. P. Deisenroth, A. A. Faisal, C. S. Ong, "Mathematics for Machine Learning", Cambridge University Press (1st Edition) , 2020.
2. S. Axler, "Linear Algebra Done Right", Springer International Publishing (3rd Edition), 2015.

Reference Book

1. Howard Anton and Chris Rorres,"Elementary Linear Algebra Applications", Wiley India, New Delhi, 2011.
2. David C Lay, "Linear Algebra and its Applications", Addison-Wesley, Boston, 2014
3. Milan Hladík, "Discrete and Continuous Optimization textbook" , Charles University Press, 2020

Semester	**II**
Subject Code	**21AD21**
Subject Title	**Fundamentals of IR 4.0**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The unit aims to cover the basics of IR4.0, building blocks, significance of data, smart systems, technologies, applications and case studies.

Course Outcome

CO1: Be able to understand the drivers and enablers of IR 4.0.

CO2: Be able to learn the concepts of intelligence in smart factories, smart production, smart cities and smart products.

CO3: Be able understand the role of AI and Data science in IR 4.0

CO4: Be able to understand the opportunities and challenges in IR4.0

Overview of IR 4.0
Different Industrial Revolutions - Drivers enablers, competitive forces in IR 4.0 - IR 4.0 development in different countries - IR 4.0 factory and conventional factory - Key trends changing IR 4.0 **(9)**
Principles and technologies in IR 4.0
Internet of Things and Industrial Internet of Things - Big data - Cloud Computing - Augmented Reality - Smart factories - Smart devices - Cybersecurity **(9)**
Cyber Physical Systems-CPS
Introduction to CPS - Elements of CPS - Functional requirements in CPS - Applications of CPS **(9)**
AI and DS in IR 4.0
Impact of AI in IR4.0 - Machine Learning Process - Categorization of Machine Learning - ML in industries - DS in industry **(9)**
Case studies and Applications
Industry 4.0 case studies - Smart manufacturing - Precision agriculture - Precision healthcare - Opportunities and challenges in IR 4.0 **(9)**
TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Sudip Misra, Chandana roy, Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0" , CRC Press, 2021

Reference Book

1. Alasdair Gilchris, "Industry 4.0: The Industrial Internet of Things", APress, 2017
2. Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin Press, 2017
3. Alec Ross, "The Industries of the Future", Simon & Schuster Press, 2016

Semester	**II**
Subject Code	**21FYC21**
Subject Title	**Environmental Science and Engineering**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C 3 0 0 1
Assessment Type	Theory
Course Objective	• To study the nature and facts about environment • To find and implement scientific, technological, economic and political solutions to environmental problems • To study the interrelationship between living organisms and the environment • To appreciate the importance of environment by assessing its impact on the human world; envision the surrounding environment, its functions and its value.

Course Outcome

CO1: An insight into the chemical reactions in water, air and soil environment

CO2: The ability to apply chemistry principles in analysing pollution of water, air and soil environment.

CO3: An understanding on the fate of chemicals on the environment and suggest relevant interventions.

CO4: An insight into the environmental protection act and the associated rules, knowledge on the institutional setup for environmental management and pollution control

NATURAL RESOURCES

Forest resources : use and over-exploitation, deforestation, Water resources : use and utilization of surface and ground water, floods, droughts and conflicts over water, dam benefits and problems – Mineral resources : use and exploitation, environmental effects of extracting and using mineral resources, Food resources : world food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizers-pesticide problems, water logging, salinity **(9)**

RENEWABLE ENERGY RESOURCE AND ENVIRONMENTAL POLLUTION

Energy resources-growing energy needs, renewable and non-renewable energy sources uses of alternative energy sources-merits and limitation of solar energy-wind and tidal energy. OTEC- Geothermal energy-Hydel energy.

Source, causes, effects and management of air pollution, water pollution, soil pollution, noise pollution, marine pollution and radioactive pollution. Solid waste Management. **(9)**

ECOSYSTEM AND BIODIVERSITY

Concept of an ecosystem-structure and functions- ecological succession, food chain, food webs and ecological pyramids; Introduction, types, characteristic features, structure and function of forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystem (Ponds, lakes, ocean and rivers). Biodiversity-types, Importance and values of biodiversity, India as a mega diversity nation, Hot spots of biodiversity, Threats to biodiversity and Conservation of biodiversity. **(9)**

ENVIRONMENTAL BIOTECHNOLOGY AND GREEN CHEMISTRY

Biotechnology and its applications in environment protection, Bioinformatics-Bioremediation, Bio deodorization, Green chemistry for clean technology. Significance of green chemistry-basic components of green chemistry. Industrial application of green chemistry-green fuels-e-green propellants and biocatalysts. **(9)**

GLOBAL ENVIRONMENTAL ISSUES AND MANAGEMENT

Water conservation, Rain water harvesting, Environmental Ethics, Climate change, Ozone depletion, Acid rain and Greenhouse effect and global warming, Environment (protection) Act, Air(prevention and control of pollution) Act, Water (prevention and control of pollution) Act, Wildlife protection Act and Forest (conservation)Act. Disaster management-Earthquakes, Floods, Landsides and cyclones. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Surinder Deswal and Anupama Deswal, “A Basic course in Environmental Studies”,2017, Dhanpat Rai & Co.
2. Anubha Kaushik and CP Kaushik, "Perspectives in Environmental Studies", 6" Edition (2015), New Age International (P) Ltd.

Reference Book

1. Benny Joseph, "Environmental Studies", (2017) 3rd Edition, McGraw Hill India.
2. Dr.S.S.Dara and Dr.D.D. Mishra, "A Text Book of Environmental Chemistry and Pollution Control", (2010), S Chand & Company.

Semester	**II**
Subject Code	**21CS21**
Subject Title	**Digital Design**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of this course is to introduce the concept of digital and binary systems and familiarize the concepts and design principles of combinational and sequential logic circuits.

Course Outcome

CO1: Understand the basics of number systems, arithmetic operations, data representation Schemes

CO2: Understand the concepts of logic gates, boolean algebra and simplify the Boolean expressions

CO3: Acquire knowledge in combinational logic and to design combinational circuits.

CO4: Ability to understand sequential logic and to design digital systems using sequential logic

CO5: Understand the various types of Memory, Memory organizations and their operations

DATA REPRESENTATION

Digital Computers and digital systems. Number system - Binary, Octal, Hexadecimal, Base Conversions. Complements-Subtraction of (unsigned) numbers using Complements. Binary Codes - BCD, Excess-3, Gray, ASCII, Error Detecting Codes- Reflected code. Fixed point Binary Data - Sign and Radix Point Representation-Signed Binary Numbers - Arithmetic Addition and Subtraction - Overflow. Decimal Data - Floating Point Data. **(9)**

BOOLEAN ALGEBRA & LOGIC GATES

Boolean Algebra - Basic Definitions – Theorems & Properties -Canonical and Standard Forms. Digital Logic gates. Simplification of Boolean Functions – Karnaugh Maps- Don't Care Conditions. NAND and NOR Implementation. Quine-McCluskey (Tabulation)Method **(8)**

COMBINATIONAL LOGIC

Design Procedure-Adders -Half Adder - Full Adder-Binary Parallel Adder-Carry Look-ahead Adder - BCD Adder. Subtractor- Half Subtractor - Full Subtractor-Magnitude Comparator-Binary Multiplier- Code Converters-Analysis Procedure- Decoders-Demultiplexers-Encoders-Priority Encoder- Multiplexers. Programmable Logic Arrays (PLA)-Programmable Array Logic(PAL) **(11)**

SEQUENTIAL LOGIC

Introduction - Flip Flops - Types -Triggering of Flip Flops. Analysis of Clocked Sequential Circuits - State Table - State Diagram - State Equation- State Reduction and Assignment. Flip Flop Excitation Tables.

Design Procedure - Design of Counters- Ripple Counters- Binary and BCD ripple counters. Synchronous counters - Binary and Binary updown counters- BCD Counters-Ring Counter-Johnson Counter. Registers – Shift Register. **(11)**

MEMORY

Memory Basics- Random Access Memory - RAM Family –Static RAMs-Memory Cell - Basic SRAM Cell Array –Cache Memory - DRAM Memory Cells – Types of DRAMs. Read-Only Memory-ROM Family Mask ROM-Simple ROM –Internal ROM Organization– Programmable ROMs.Flash Memory- Flash Memory Cell-Flash Memory Operation-Basic Flash Memory Array-Comparison of Flash Memories with other Memories. **(6)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. M. Morris Mano, “Digital Logic and Computer Design”, Pearson Education, 1st edition, 2016.
2. Thomas L.Floyd, “Digital Fundamentals", Pearson Education; Eleventh edition, 2017. (For “MEMORY” Only).

Reference Book

1. Charles H. Roth Larry L. Kinney, Raghunandan G. H. “Fundamentals of Logic Design”, Cengage Learning, 1st edition, 2019.
2. Tocci R.J., Neal S. Widemer, Gregory L. Moss “Digital Systems: Principles and Applications”, Prentice Hall of India, 12th edition, 2016.
3. V.Rajaraman, T.Radhakrishnan, “Digital Logic and Computer Organization”, PHI Learning Pvt. Ltd, 2009. (For “Programmable Logic Arrays”).

Semester	**II**
Subject Code	**21CSL22**
Subject Title	**Python Programming**
Duration	One Semester
Total Contact Hours	75 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 1 0 4 3
Assessment Type	Theory
Course Objective	The subject objective is to cover the concepts of python programming to solve computational problems

Course Outcome

CO1: Understand the fundamental concepts of computers and basic blocks of programming.
CO2: Apply control statements, decision making statements to solve the given problems.
CO3: Usage of complex data types in python to develop on application.
CO4: Practice problem solving using functions and string operations.
CO5: Solve the real - world problems using file handling operations, modules, packages and error handling methods.

INTRODUCTION TO PROGRAMMING

Introduction to Computers - Fundamentals of Programming: Algorithm, Flowchart, Structured Programming, Object Oriented Programming. Python Introduction: Python variables, Python basic Operators, Understanding python blocks. Python Data Types, Declaring and using Numeric data types: int, float etc. **(3)**

PYTHON STATEMENTS

Assignment statements, I/O statements. Control statements: if, else and else if, for loops, for each, While loops, Loop manipulation using pass, continue, break and else. **(3)**

PYTHON COMPLEX DATA TYPES

Lists: List operations, List slices, List methods, List loop, mutability, aliasing, cloning lists, list parameters. Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; Set: Creating Sets, Performing Set Operations: Union, Intersect and Difference. **(3)**

FUNCTIONS & STRING MANIPULATIONS

Functions: Parameters, Local and Global scope, Return values, Recursion. String operations: Subscript operator, Indexing, Slicing a string, Strings and Number system: Converting strings to numbers and vice versa. Using ASCII and Unicode Strings, Manipulating Strings with String Methods, format() Function, Escape Sequences. **(3)**

FILES, MODULES AND PACKAGES

Files: Text files, reading and writing files, Format operator; Command line arguments, Errors and Exceptions, Handling Exceptions, Modules: import Statement, from...import Statement, **Packages:** Numpy, Scipy. **(3)**
Theory : 15; Practical : 60 **TOTAL: 60 + 15 = 75**

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. John V. Guttag, "Introduction to Computation & Programming using Python", 2nd Edition, The MIT Press. 2016
2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist". 2nd edition, Updated for Python 3. Shroff O'Reilly Publishers, 2016.
3. Guido van Rossum and Fred L. Drake Jr., “An Introduction to Python — Revised and updated for Python 3.2". Network Theory Ltd., 2011.

Reference Book

1. Mark Lutz. "Learning Python", 5th edition. Orelly Publication, 2013.
2. John Zelle, "Python Programming: An Introduction to Computer Science", 2nd edition. Course Technology Cengage Learning Publications. 2013.
3. Michel Dawson, "Python Programming for Absolute Beginners", 3rd Edition. Course Technology Cengage Learning Publications, 2013.
4. David Beazley Brian Jones.. "Python Cookbook". 3rd Edition. Oreilly Publication. 2013.

Semester	**II**
Subject Code	**21MEL11**
Subject Title	**Engineering Graphics**
Duration	One Semester
Total Contact Hours	75 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 1 0 4 3
Assessment Type	Theory
Course Objective	• To introduce the students to the "universal language of Engineers" for effective communication through drafting exercises of different geometrical shapes. • To develop the ability to communicate with others through the language of technical drawing and sketching. • To enable the students with various concepts like dimensioning. Conventions and standards related to working drawings in order to become professionally efficient.

Course Outcome

CO1: Understand the importance of BIS and ISO Standards in Engineering Drafting.
CO2: Imagine and visualize the geometric details of engineering objects.
CO3: Communicate ideas through technical drawings.
CO4: Use computer aided drafting in their respective engineering field.
CO5: Interpret Orthographic and Isometric views of objects.

INTRODUCTION TO ENGINEERING DRAWING

Principles of Engineering Graphics and their significance, usage of drawing instruments and Lettering, dimensioning and scales. **(7)**

ORTHOGRAPHIC PROJECTIONS

Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes. **(15)**

PROJECTIONS OF REGULAR SOLIDS

Projections of solids Inclined to both the Planes - Draw simple annotation. **(15)**

SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES

Sections - Prism, Cylinder, Pyramid, Cone; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone. **(15)**

ISOMETRIC PROJECTIONS	
Principles of Isometric projection — Isometric Scale, Isometric Views, Conventions; Isometric Views of simple Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa. **(15)**	
OVERVIEW OF COMPUTER GRAPHICS	
Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]. **(8)**	
	TOTAL: 60 + 15 = 75
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. K. Venugopal and V. Prabhu Raja, Engineering Graphics, NewAge International Publishers, 2017.

Reference Book

1. Bhatt N.D., Panchal V.M. & Ingle PR.,"Engineering Drawing", Charotar Publishing House. 2014.
2. Shah. M.B. &Rana B.C., "Engineering Drawing and Computer Graphics", Pearson Education, 2008.
3. Agrawal B. &Agrawal C. M., "Engineering Graphics", TMH Publication. 2012.
4. Narayana. K.L. & P Kannaiah,"Text book on Engineering Drawing", SciTech Publishers. 2008.

<table>
<tr><td>Semester</td><td>II</td></tr>
<tr><td>Subject Code</td><td>21PL21</td></tr>
<tr><td>Subject Title</td><td>Physics Laboratory II</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>30 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>N/A</td></tr>
<tr><td>Credit Points</td><td>0.5 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td>
<table>
<tr><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>0.5</td></tr>
</table>
</td></tr>
<tr><td>Assessment Type</td><td>Practicals</td></tr>
<tr><td>Course Objective</td><td>To make students to understand the basic concepts of matter, light, electricity and semiconductors and acquire experimental skills by carrying out experiments.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: Will be able to gain a fundamental understanding of the apparatus used in the experiments and recognize how observations, experiment and theory work together</td></tr>
<tr><td colspan="2">EXPERIMENTS BASD ON THE FOLLOWING TOPICS</td></tr>
<tr><td colspan="2">1. Implementation of Basic Logic Gates using Universal Gates.
2. Study of I-V characteristics of Solar Cell and Determination of its efficiency.
3. LASER - Determination of wavelength.
4. Young's Modulus- cantilever
5. Study of charging and discharging of a capacitor.
6. Determination of Specific Resistance.
7. Determination of Numerical aperture of an Optical fibre (Demonstration Experiment).</td></tr>
<tr><td colspan="2">TOTAL: 30</td></tr>
<tr><td>Minimum Requirement to pass the subject</td><td>To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.</td></tr>
</table>

Semester	**II**
Subject Code	**21CL21**
Subject Title	**Chemistry Laboratory II**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	N/A
Credit Points	0.5 CP
Learning and Teaching Structure	L T P C 0 0 2 0.5
Assessment Type	Practicals
Course Objective	• To help the students to understand the principles involved in complexometric titration. • To learn the principles such as flame photometry, spectrophotometry and potentiometry. • To understand and appreciate the working of spectrophotometer, flame photometer and potentiometer.

Course Outcome

CO1: By performing EDTA titrations, the students could understand how hardness producing salts create boiler troubles and how to quantify hardness producing ions present in raw water.

CO2: By the determination of weight loss method, the student will be able calculate rate of corrosion

CO3: Students are able to handle analytical tools such as spectrophotometer, flame photometer, conductometer and potentiometer.

EXPERIMENTS BASD ON THE FOLLOWING TOPICS

1. Determination of sodium in water sample by flame photometry.
2. Estimation of iron in water sample by spectrophotometry.
3. Estimation of Calcium using Eriochrome Black -T indicator Substitution method
4. Determination of corrosion rate of steel in acid media by weight loss method
5. Estimation of acid in a mixture by conductometry.
6. Estimation of ferrous ion by potentiometric titration

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Semester	**II**
Subject Code	**21CSL21**
Subject Title	**Digital Design Laboratory**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	To analyze the working philosophies of Sequential and Combinatorial circuits.

Course Outcome

CO1: Understand the operations of logic gates and verify Boolean algebra theorems

CO2: Ability to design combinational digital circuits like adder, subtractor, decoders, encoders, multiplexers, and de-multiplexers.

CO3: Construct and analyze sequential digital circuits like flip-flops, registers, and counters.

EXPERIMENTS BASD ON THE FOLLOWING TOPICS

1. Realization of AND, OR and NOT gates using Universal gates.
2. Verification of Boolean algebra theorems and postulates.
3. Design of Half adder, Full adder, Half subtractor and Full subtractor.
4. Design of combinational circuits using NAND and NOR gates.
5. Design of code converter.
6. Design of Encoders, Decoders, Multiplexer and De-Multiplexer circuits.
7. Design and implementation of Priority Encoder.
8. Implementation of Boolean functions using 4x1 Multiplexer.
9. Realization of R-S, J-K, D and T Flip flops.
10. Design of Counters.
11. Design of Shift registers.
12. Simple VHDL programming.

TOTAL: 30

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Semester	**II**
Subject Code	**21FYEL21**
Subject Title	**English for Employability**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Theory
Course Objective	The objective of this course is to prepare students for gaining English proficiency in both written as well as oral form of language to scale greater heights in their chosen career.

Course Outcome

CO1: Solve timed objective questions on logical reasoning and verbal ability.

CO2: Generate ideas and speak confidently, for a given speaking task on topics JAM, Describing an Object, Book Review, and Extempore.

CO3: Use appropriate functional language, for a given social situation viz., travel and transport, complaining, giving instructions, advising and sympathizing, requesting and warning people.

CO4: Generate valid points for and against the topic and present them with appropriate group behaviour, for a given HR topic.

CO5: Plan and prepare a 20 min HR mock interview, for any job requirement.

UNIT – 1

Ice Breakers - Just a Minute - Book Reviews - Describing an object – Extempore – Paraphrasing **(6)**

UNIT – II

Spoken English - Travel and Transport, Complaining - Giving Instructions, Advising and Sympathizing – Requesting and warning people **(5)**

UNIT – III

Logical Sequence of Words- Exercises - Sequential Order of Things - Comparison Type Questions – Introduction and Exercises - Idioms and Phrases - Types and Exercises - Vocabulary through Mythology - One word Substitutes, Word Power Exercises - Common Errors in English - Sentence Correction **(7)**

UNIT – IV

Activity based on newspaper articles - Vocabulary – Homophones and Homonyms - Reading Prose – Reading Comprehension Activity **(4)**

UNIT – V

Professional Communication - Mock Group Discussion – Mock Interview – Telephoning Skills – Personality Development Activities **(8)**	
TOTAL: 30	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

<table>
<tr><td>Semester</td><td>III</td></tr>
<tr><td>Subject Code</td><td>21AD31</td></tr>
<tr><td>Subject Title</td><td>Probability and Statistics</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>60 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>N/A</td></tr>
<tr><td>Credit Points</td><td>4 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>1</td><td>0</td><td>4</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The goal of this course is for students to
To introduce the concept of probability and distributions which will then be used to solve related problems.
To give an integrated approach to two dimensional random variables and provide a firm basis for further reading and study in the subject.
To provide the required mathematical support in real life problems and develop sampling theory which can be used in several areas of machine learning.
To extend Logical, Mathematical maturity and ability to deal with abstraction and to introduce most of the basic charts used in computer science courses and application of ideas to solve practical problems.
To provide the required skill to apply the concepts of reliability in real life problems.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: Assimilate ideas of probability distributions and solve natural problems using various Statistical measures.
CO2: Associate random variables and distributions and to apply the principles of regression and correlation for data analysis and modelling
CO3: Formulate and test the hypothesis about means, variances and proportions and draw conclusions based on the results of statistical tests
CO4: Incorporate the ideas of statistical process control that are imperative for the effective understanding of scientific problems.
CO5: Familiar in applying reliability theory to solve real life problems</td></tr>
</table>

PROBABILITY

Probability-Conditional probability - Baye's theorem - One dimensional random variable-Discrete random variable-probability Mass Function-Continuous Random variable-Probability Density function – Cumulative Distribution function Discrete distributions – Binomial distribution –Poisson distribution - Geometric distribution- Continuous distributions – uniform distribution - exponential distribution - normal distribution

(9 + 3)

TWO DIMENSIONAL RANDOM VARIABLES

Two dimensional random variables-Joint probability density function –-Marginal and conditional probability distribution – covariance and correlation of two-dimensional random variables. **(9 + 3)**

SAMPLING THEORY

Large samples –Testing of hypothesis about population mean-difference between two means-two Standard deviations

Small samples – t-distribution -Testing of hypothesis about the population mean- difference between two sample means-F-distribution - Testing of hypothesis for equality of two Variances –Chi-Square Distribution –Test for goodness of fit –Independence of Attributes

(10 + 3)

STATISTICS QUALITY CONTROL

Statistical basis for control charts-Control Charts for variables – Control for the sample Mean $\bar{X}$ -Chart and Sample Range R-Chart – Control chart for sample Standard deviation s-Chart – Control charts for Attributes: Control chart for proportion of defectives p- Chart-Chart for number of defectives np- Chart and Control chart for the number of defectives in a unit c- Chart **(10 + 4)**

RELIABILITY

Concept of reliability - hazard rate - mean time to failure - standard reliability models - series and parallel system reliability – simple problems using basic R programming **(7+2)**

Theory : 45; Tutorial : 15;
TOTAL : 45 + 15 = 60

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS:

1. Jay L Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, 2015.
2. Amitava Mitra, "Fundamentals of quality control and improvement", John Wiley & Sons, Inc., Hoboken, New Jersey, 4th edition .2016.

REFERENCE BOOKS

1. Saeed Ghahramani, “Fundamentals of Probability with Stochastic Processes”, Pearson Education, 2014.
2. Richard A. Johnson, “Probability and Statistics for Engineers and Scientists”, Prentice Hall, 2011.
3. Ronald E. Walpole, Raymond H. Meyers, Sharon L. Meyers, “Probability and Statistics for Engineers and Scientists”, Pearson Education, 2012.

Semester	**III**
Subject Code	**21AD32**
Subject Title	**Data Structures and Algorithms**
Duration	One Semester
Total Contact Hours	60 Hours per semester
Pre-Requisite	N/A
Credit Points	4 CP
Learning and Teaching Structure	L T P C 3 1 0 4
Assessment Type	Theory
Course Objective	The objective of the course is to introduce the fundamental concepts of data structures particularly emphasizing on devising optimal algorithms. Also to gain potential ability to assess how the choice of data structures and algorithm design methods impacts the performance of programs.

Course Outcome

CO1: Learn the fundamental data structures such as lists, stacks, queues, trees, graphs and associated algorithms

CO2: Choose the Data Structures and Algorithms that are appropriate for different applications

CO3: Analyze the computational complexity of computer algorithms

DATA, INFORMATION AND ALGORITHM ANALYSIS

Data Vs Information - Representation of Numbers: Integer, Real, Representation of Characters - Definition of an Algorithm - Basic Steps in Development of an Algorithm - Algorithm Notations - Sparks - Algorithm Complexity - Space and Time Complexity - Order Notations - Definition of NP Hard - NP Complete. **(6)**

LINEAR LIST

Definition - Arrays: Representation and Characteristics - Array of Structures - Polynomial Representation- Multidimensional Arrays. **(3)**

STACKS AND QUEUES

Fundamentals of Stacks, Queues and Dequeues - Application of Stacks: Recursion - Conversion of Infix to Postfix and Prefix Expressions - Evaluation of Postfix Expressions - Application of Queues: Wire Routing-Priority Queue-Multiple Stacks and Queues. **(7)**

LINKED LISTS
Singly and Doubly Linked Lists: Basic Operations - Linked Stacks and Queues - Polynomial Manipulation-Multi precision Arithmetic- Equivalence Relations. **(6)**
SPARSE MATRICES
Representation - Transpose and Multiplication of Sparse Matrices in Three Tuple Form - Sparse Matrices using Linked Lists. **(5)**
CHARACTER STRINGS
Representation: Fixed Length, Workspace Index, Linked List - Operations: Concatenation, Insertion, Deletion, Sub-String, Pattern Matching. **(4)**
SORTING
Types of Sorting- Sorting algorithms: Bubble, Selection, Insertion- Divide and conquer sorting: Merge, Quick and Heap - Analysis of all sorting algorithms **(4)**
TREES
Definition - Binary Trees: Representations, Traversal, Properties - Threaded Binary Trees - Copying and Equivalence of Binary Trees - Binary Tree Representation of General Trees - Application of Trees: Binary Search Trees: Principle, Addition and Deletion of Nodes, Decision Trees, Game Trees. **(5)**
GRAPHS
Terminology and Representations - Warshall Algorithm - Traversals – Bi connectivity - Connected Components - Spanning Trees -Shortest Path - Transitive Closure- Activity Networks -Topological Sort -Critical Paths-Enumerating all Paths-Euler and Hamiltonian Paths. **(5)**
* Note: Algorithms will be taught in Sparks like notation.
Theory : 45; Tutorial : 15; **TOTAL: 60**

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Ellis Horowitz, Sartaj Sahni, "Fundamentals of Data Structures", Galgotia Publications, Second Edition, 2008.

Reference Book

1. Satraj Sahani, "Data structures, Algorithms and applications in C++", McGraw Hill, Second Edition, 2005.
2. Jean-Paul Tremblay and Paul G. Sorenson, "An Introduction to Data Structures with Applications", McGraw Hill, Second edition, 2008.

Semester	**III**
Subject Code	**21AD33**
Subject Title	**Principles of Artificial Intelligence**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of the course is about knowing how to realize the intelligent human behaviours on a computer. The goal is to acquire knowledge on intelligent systems and agents, formalization of knowledge, reasoning with and without uncertainty, machine learning and applications at a rudimentary level

Course Outcome

CO 1: Illustrate real-world problems from the perspective of intelligent agents to achieve problem oriented Goal.

CO 2: Apply various informed search strategies in optimal decision making.

CO 3: Employ first-order logic for building knowledge base to infer reasoning using knowledge Engineering.

CO 4: Describe representation of uncertain knowledge, Bayesian Networks and Temporal models.

CO 5: Describe several learning algorithms to improve the performance of intelligent agents.

INTRODUCTION

Foundation of AI - Agents and Environments - Concept of Rationality - Nature of Environments - Structure of Agents - Problem- Solving Agents and examples - Uninformed Search Strategies - Searching with Partial Information. **(8)**

SEARCH TECHNIQUES

Search Strategies : A*Search - Heuristic Functions-Local Search Algorithms and Optimization Problems – Constraint Satisfaction Problems – Backtracking Search for CSPs –Local Search for Constraint Satisfaction Problems – Structure of Problems – Games - Optimal Decisions in Games –Alpha – Beta Pruning. **(8)**

KNOWLEDGE AND REASONING

Logic -Propositional Logic - Syntax and Semantics of First-Order Logic - Using First-Order Logic - Knowledge Engineering in First-Order Logic – Propositional vs. First-Order Inference-Forward Chaining-Backward Chaining-Resolution. **(8)**

UNCERTAIN KNOWLEDGE AND REASONING

Acting under uncertainty - Bayes' rule and Its use – Representing Knowledge in an Uncertain Domain – The Semantics of Bayesian Networks – Exact Inference in Bayesian Network – Approximate Inference in Bayesian Networks – Hidden Markov Models – Kalman Filters. **(9)**

LEARNING

Forms of Learning - Learning Decision Trees-Artificial Neural Networks-Ensemble Learning-Logical Formulation of Learning- Knowledge in Learning - Explanation -Based Learning -Learning Using Relevance Information - Inductive Logic Programming - Statistical Learning -Learning with Complete Data -EM Algorithm- Passive Reinforcement Learning-Active Reinforcement Learning. **(9)**

EXPLAINABLE AI

Introduction to Explainable AI- Methods of Explainable AI- Ethical and Legal Issues in Explainable AI **(3)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Stuart J Russell and Peter Norvig, "Artificial Intelligence- A Modern Approach", Pearson Education Series, Third Edition, 2010.

Reference Book

1. Deepak Khemani, "A First Course in Artificial Intelligence", McGraw Hill Education, First Edition, 2013.
2. Dan W. Patterson "Introduction to AI and ES", Pearson Education, First Edition, 2007
3. Patrick Henry Winston, "Artificial Intelligence", Addison Wesley publishers, Third Edition, 1992.
4. Elaine Rich, Kevin Knight and Shiva Shankar, "Artificial Intelligence", McGraw Hill, Third Edition, 2009.

Semester	**III**
Subject Code	**21AD34**
Subject Title	**Software Engineering Principles and Practices**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The aim of the subject is to provide a brief overview of software development lifecycle, process and provides the learners on understanding of how to manage software projects.

Course Outcome

CO1: Be able to understand the common key issues in software development process

CO2: Be able to gather requirements for a software product and translate it into an architecture.

CO3: Be able to understand the importance of testing and reusability in the implementation phase and how all these activities are related to each other in software development

CO4: Be able to understand the traditional and agile practices in software industry

SOFTWARE ENGINEERING OVERVIEW AND LIFECYCLE

Introduction to Software Engineering - Evolution and Software Myths - Phases in the Development of Software - Software Lifecycle Models: The waterfall model, spiral model, incremental process models, evolutionary process models, the unified process – AI Software Development lifecycle **(9)**

SOFTWARE REQUIREMENT ENGINEERING

Requirements Elicitation - Requirements Elicitation Techniques - Requirements Management - Requirements Specification Techniques - Requirement Validation and Verification **(9)**

SOFTWARE DESIGN

Classic Modelling Techniques - The Unified Modelling Language - Architecture design - Architectural views - Design Considerations - Classical Design Methods - Object-Oriented Analysis and Design Method - Design Verification and Validation **(9)**

SOFTWARE TESTING

Programming principles and guidelines - Testing Fundamentals - Black Box Testing: Equivalence Class Partitioning, Boundary Value Analysis - White box Testing: Control Flow based criteria Data Flow based Testing - Levels of Testing: Unit Testing, Integration Testing, System Testing , Acceptance Testing - Different Testing Stages **(9)**

SOFTWARE QUALITY

Quality concepts, software quality assurance and software reviews - The Capability Maturity Model (CMM) - Formal technical reviews - Statistical software quality assurance - Software reliability - The ISO 9000 quality standards - Agile best practices for building quality software. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Roger S. Pressman, "Software Engineering, A practitioner's Approach" 8th Edition, Mc Graw Hill International Edition, 2015.
2. Sommerville, "Software Engineering", 10th Edition, Pearson Education, 2016.

Reference Book

1. Waman S Jawadekar, "Software Engineering principles and practice", The Mc Graw-Hill Companies, 2004.
2. Ronald J. Leach, "Introduction to Software Engineering", 2nd Edition , Routledge, 2016
3. Hans van Vliet, "Software Engineering: Principles and Practice", Willey, 2007

Semester	**III**
Subject Code	**21AD35**
Subject Title	**Web Development Technologies**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To gain knowledge in client-server communication and protocols and the ability to design interactive web pages using scripting languages.

Course Outcome

CO1: Design simple web pages using markup languages like HTML and XHTML.
CO2: Create dynamic web pages using DHTML and java script that is easy to navigate and use.
CO3: Program server side web pages that have to process request from client side web pages.
CO4: Represent web data using XML and develop web pages using JSP.
CO5: Understand various web services and how these web services interact.

WEB SITE BASICS AND HTML

Web Essentials: Clients, Servers, and Communication. The Internet-Basic Internet Protocols -The World Wide Web-HTTP request message-response message-Web Clients Web Servers. Markup Languages: XHTML. An Introduction to HTML History-Versions-Basic XHTML Syntax and Semantics-Some Fundamental HTML Elements-Relative URLs-Lists-tables-Frames-Forms-HTML 5.0. **(9)**

CSS AND CLIENT SIDE SCRIPTING

Style Sheets: CSS-Introduction to Cascading Style Sheets-Features-Core Syntax-Style Sheets and HTML- Style Rule Cascading and Inheritance-Text Properties-Box Model Normal Flow Box Layout-Beyond the Normal Flow-CSS3.0. Client-Side Programming: The JavaScript Language-History and Versions Introduction JavaScript in Perspective-Syntax-Variables and Data Types-Statements-Operators-Literals-Functions-Objects-Arrays-Built-in Objects-JavaScript Debuggers- Overview of Bootstrap- Bootstrap CSS component-Bootstrap JavaScript component. **(9)**

SERVER SIDE SCRIPTING

Host Objects: Browsers and the DOM-Introduction to the Document Object Model DOM History and Levels-Intrinsic Event Handling-Modifying Element Style-The Document Tree-DOM Event Handling-Accommodating Noncompliant Browsers Properties of window. Server-Side Programming: Java Servlets- Architecture -Overview-A Servlet-Generating Dynamic Content-Life Cycle- Parameter Data-Sessions-Cookies-URL Rewriting-Other Capabilities-Data Storage Servlets and Concurrency- Databases and Java Servlets. **(9)**

JSP AND XML

Separating Programming and Presentation: JSP Technology Introduction-JSP and Servlets-Running JSP Applications Basic JSP-JavaBeans Classes and JSP-Tag Libraries and Files-Support for the Model-View-Controller Paradigm- Databases and JSP. Representing Web Data: XML-Documents and Vocabularies-Versions and Declaration-Namespaces- DOM based XML processing Event-oriented Parsing: SAX-Transforming XML Documents-Selecting XML Data: XPATH-Template based Transformations: XSLT-Displaying XML Documents in Browsers. **(9)**

AJAX AND WEB SERVICES

AJAX: Ajax Client Server Architecture-XML Http Request Object-Call Back Methods. Web Services: JAX-RPC-Concepts-Writing a Java Web Service-Writing a Java Web Service Client-Describing Web Services: WSDL- Representing Data Types: XML Schema-Communicating Object Data: SOAP Related Technologies-Software Installation-Storing Java Objects as Files. **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Books

1. Jeffrey C. Jackson, “Web Technologies–A Computer Science Perspective”, Pearson Education, 2006.

Reference Books

1. Robert. W. Sebesta, “Programming the World Wide Web”, Fourth Edition, Pearson Education, 2007.
2. Deitel, Deitel, Goldberg, “Internet and World Wide Web How To Program”, Third Edition, Pearson Education, 2006.
3. Marty Hall and Larry Brown, Core Web Programming Second Edition, Volume I and II, Pearson Education, 2001.

Semester	**III**
Subject Code	**21AD36**
Subject Title	**Science of Creativity and Professional Ethics**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C 1 1 0 1
Assessment Type	Theory
Course Objective	The objective of the course is to develop positive attitudes towards learning and teaching science.

Course Outcome

CO1: Describe the principles of karma yoga and functioning of mind and consciousness

CO2: Hypothesize the evolution of Universe and living beings in a global and societal context

CO3: Infer the principles of Yoga to practice it and know the value of health.

CO4: Interpret the philosophy of introspection procedures for better living

CO5: Assess, take personal responsibility and follow professional ethics for sustained growth in career and life.

LIFE FORCE, MIND AND CONCIOUSNESS

Science of Creativity and Personality Development - Objectives - Principles of Karma Yoga - Duty Consciousness – Communism and Capitalism - Law of Nature - Life Force - Origin - Potentiality of the Life Force - Premordial State - Wave Theory - Consciousness - Pancha Thanmatras - Secret of Revelations - Mind - Biomagnetism - Physical Transformation of Biomagnetism. **(7)**

EVOLUTION OF THE UNIVERSE AND LIVING BEINGS

Evolution of the Universe: Creation Theory - Evolution Theory - Theory of Permanence - Theory of Mithya - Evolution of Living Beings: Absolute Space and Force - Plants Experience Pain - Two Eyes and Two Ears - Seven Constituent Layers in the Body. **(5)**

YOGA AND ITS BENEFITS

Simple and Safe Yoga - Upa Yoga Practices: Yoga for Peace - Yoga for Health - Yoga for Joy - Yoga for Love - Yoga for Wellbeing - Yoga for Success. Physical Exercise - Meditation - Seven Centers of Meditation - Benefits - Effect of Good Vibrations - Cause and Effect System -Food and Health. **(6)**

INTROSPECTION	
Attachment, Detachment and Moderation in Enjoyment - Imaginary Expectations - Harmony in Life: Self, Family, Society and Nature - Introspection: Analysis of Thought, Moralization of Desire, Neutralization of Anger, Eradication of Worries and Self Realization. **(6)**	
HUMAN VALUES	
Morals, Values and Ethics - Integrity - Work Ethics - Service Learning - Virtues - Respect for Others - Living Peacefully – Caring - Sharing - Honesty - Courage - Valuing Time - Co-operation - Commitment - Empathy - Self Confidence - Challenges in Work Place - Impact of cyberspace on individuals. **(6)**	
	TOTAL: 30
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Yogiraj Vethathri Maharishi, "Karma Yoga - The Holistic Unity", Vethathri Publications, IV Edition, 2009. (Chapters 1-7, 10-12)
2. R.S.Naagarazan, "A Textbook on Professional Ethics and Human Values", New Age International Publishers, New Delhi, 2011.

Reference Book

1. Sadhguru, "Body the Greatest Gadget and Mind is your Business", Diamond Pocket Books Pvt. Ltd, Isha Foundations, 2013.
2. Swami Vivekananda and Swami Nikhilananda, "Karma Yoga and Bhakti Yoga", II Edition, Ramakrishna Vivekananda Publications, 2008.
3. Henry Dreyfuss, "The Measure of Man and Woman: Human Factors in Design", John Wiley and Sons Publications, 2012.
4. Mike W. Martin and Roland Schinzinger,"Ethics in Engineering", IV Edition, McGraw Hill, NewYork, 2005.
5. M. Govindarajan, S. Natarajan, V.S. Senthilkumar, "Engineering Ethics", I Edition, Prentice Hall of India, 2009.

Semester	**III**
Subject Code	**21ADL37**
Subject Title	**Data Structures and Algorithms Laboratory**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	1.5 CP
Learning and Teaching Structure	L T P C 0 0 3 1.5
Assessment Type	Practical
Course Objective	The objective is to have rigorous foundations in DS concept like Stack, Queues, Linked list and to view real-world problems in algorithmic perspective.

Course Outcome

CO1: Selection and application of suitable data structures in implementing practical problems.

CO2: Apply searching and sorting algorithms that suit the given problem stated

CO3: Identify suitable graph based algorithms and apply them for solving problems that arise in the real world scenarios

EXPERIMENTS USING THE FOLLOWING CONCEPTS

1. Operations on Stacks, Queues and Linked List
2. Applications using Stacks and Queues
3. Polynomial operations using Linked List
4. Trees - Binary Tree Traversals, Binary Search Tree operations
5. Traversals on graphs
6. Implementation of shortest path algorithms in Graph
7. Implementation of suitable search algorithms for the given applications
8. Implementation of sorting algorithms

Software Required: gcc compiler

Semester	**III**
Subject Code	**21ADL38**
Subject Title	**Web Development Laboratory**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	1.5
Learning and Teaching Structure	L T P C 0 0 3 1.5
Assessment Type	Practicals
Course Objective	The course objective is to make students to design interactive web pages using scripting languages.

Course Outcome

CO1: Design simple web pages using markup languages like HTML and XHTML.
CO2: Create dynamic web pages using DHTML and java script that is easy to navigate and use

EXPERIMENTS USING THE FOLLOWING CONCEPTS

1. Create a web page with the following using HTML.
   - To embed an image map in a web page.
   - To fix the hot spots.
   - Show all the related information when the hot spots are clicked
2. Create responsive web page with all types of Cascading style sheets and BOOTSTRAP.
3. Client Side Scripts for Validating Web Form Controls using DHTML.
4. Installation of Apache Tomcat web server.
5. Write programs in Java using Servlets:
   - To invoke servlets from HTML forms.
   - Session Tracking.
6. Write programs in Java to create three-tier applications using JSP and Databases
   - For conducting on-line examination.
   - For displaying student mark list. Assume that student information is available in a database which has been stored in a database server.
7. Programs Using Xml – Schema – Xslt/Xsl.
8. Programs using DOM and SAX parsers.
9. Programs using AJAX.
10. Consider a case where we have two web Services- an airline service and a travel agent and the travel agent is searching for an airline. Implement this scenario using Web Services and Data base.

Software Requirement : Java, Web Server (*intimated by the corresponding lab course instructor*)

Semester	**IV**
Subject Code	**21AD41**
Subject Title	**Discrete Mathematics & Automata Theory**
Duration	One Semester
Total Contact Hours	60 Hours per semester
Pre-Requisite	N/A
Credit Points	4 CP
Learning and Teaching Structure	L T P C 3 1 0 4
Assessment Type	Theory
Course Objective	The Goal of this Course is to a) Improve logical and mathematical maturity and ability to deal with abstraction b)Understand the basic concepts of Inference Theory c) Introduce most of the basic terminologies used in computer science courses and application of ideas to solve practical problems d) Familiarize the applications of algebraic structures and Coding Theory which have applications in computer science and engineering e) Gain the knowledge to deploy specification of language using grammar

Course Outcome

CO1: Apply logical reasoning in verifying the correctness and validity of simple instances of valid logical arguments.

CO2: Learn the basic concepts of Inference theory and Predicate Calculus to acquire knowledge to solve the problems.

CO3: Solve permutations and combinations problems using the counting principle and Recursion relation to solve the problems.

CO4: Illustrate various algebraic structures and their properties and design encoding and decoding procedures for error detection and correction.

CO5: To acquire knowledge in constructing system models which are the natural extension of Automata that is used to devise decision procedures.

MATHEMATICAL LOGIC

Connectives – Statement Formulas and Truth tables- Well formed formulas- Tautologies- Equivalence of Formulas-Duality Law- Tautological Implications- Functionally complete sets of connectives- other Connectives- Disjunctive and Conjunctive normal forms- Principals of Disjunctive and Conjunctive normal Forms. **(9)**

INFERENCE THEORY AND PREDICATE CALCULUS

Rules of inferences – Consistency of premises and indirect method of proof – Predicate Calculus- Variables and Quantifiers- Theory of Inference for the Predicate Calculus – Formulas Involving more than one Quantifier. **(9)**

ALGEBRAIC STRUCTURES I

Rings, Integral domains and Fields - Properties - Polynomial Rings - Construction of Finite Fields ; Irreducible Polynomials - Primitive element of a Finite Field - Primitive Irreducible Polynomials. **(9)**

ALGEBRAIC STRUCTURES II

Residue arithmetic for Computers - Coding theory - Error Detection - Correction – Hamming Distance - Minimum distance - Group Code, Linear Code and Cyclic Codes – Single error correction; Encoding and Decoding Techniques. **(9)**

FINITE AUTOMATA AND TURING MACHINES

Chomsky Classification of Grammars- Finite State systems – Basic definitions – Transition diagrams – Deterministic & Nondeterministic Finite Automata – Finite Automata with Є moves- Turing Machines: The Turing Machine Model – Addition of unary numbers – Multiplication of unary numbers – Recognition of binary palindromes – Recognition of words of the form 0n , 1n. **(9)**

Theory: 45; Tutorial: 15;

TOTAL: 60

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Tremblay J.P and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", Tata Mc Graw Hill Pub.Co. Ltd,New Delhi, 30th Reprint, 2011.
2. John E.Hopcroft, Rajeev Motwani, Jeffery D.Ullman, " Introduction of Automata Theory, Languages and Computation", Addison Wesley, Pearson Education, 3rd edition , Second Impression,2009.

Reference Book

1. Kenneth H Rosen, “Discrete Mathematics with Applications”, Tata McGraw Hill, 8thEdition, 2021.
2. K.L.P Mishra, N.Chandrasekaran “ Theory of Computer Science”, Prentice,Hall of India Private Limited, Third Edition, 2006.
3. Grimaldi R.P, “Discrete and Combinatorial Mathematics: An Applied Introduction”, Pearson Education Asia, Fifth Edition, Delhi, 2019.
4. John.C.Martin, “Introduction to Languages and the Theory of Computation”, Third Edition, Tata Mcgraw-Hill, seventh reprint,2010.

Semester	**IV**
Subject Code	**21AD42**
Subject Title	**Machine Learning Techniques**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21FYM21 - Linear Algebra and Gradient Calculus 21AD31 – Probability and Statistics
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To provide an understanding of the theoretical concepts of machine learning and prepare students for research or industry application of machine learning techniques.

Course Outcome

CO1: To Learn the basic principles of machine learning techniques

CO2: To Understand the strengths and weaknesses of machine learning algorithms

CO3: To Study the concepts of dimensionality reduction and Bayesian

CO4: To Design and implement neural network and clustering algorithms

CO5: To Understand the basics of computation and ensemble learning techniques

INTRODUCTION TO MACHINE LEARNING

Introduction- Types of Machine Learning- Application of Machine Learning- Hypothesis Space -Inductive Bias- Evaluation and Cross Validation. **(9)**

MACHINE LEARNING ALGORITHMS

FIND S Algorithm - Candidate-Elimination algorithm- Linear Regression- Logistic Regression- Decision Tree- Decision Tree Learning- K-Nearest Neighbour- Support Vector Machine- Collaborative Filtering- Overfitting

(9)

DIMENSIONALTY REDUCTION AND BAYESIAN CONCEPTS

Dimensionality Reduction: Feature and Feature Engineering- Feature Transformation - Feature Subset Selection- Importance of Bayesian Methods: Bayes Theorem - Bayes Theorem and Concept -Learning- Bayes Belief Network

(9)

NEURAL NETWORK AND CLUSTERING

Introduction to Neural Network- Biological Neurons- Architectural of Neural Network- Implementation of ANN -Back propagation Algorithm – Introduction to Clustering, Hierarchical Clustering -Agglomerative Clustering . **(9)**
COMPUTATION AND ENSEMBLE LEARNING
Introduction to Computation Learning -Sample complexity: Finite Hypothesis Space- VC Dimensions- Introduction to Ensemble Learning **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. I. A. Dhotre , Introduction to Machine learning, Technical Publication, 2022
2. T. Mitchell, Machine Learning, McGraw Hill, 1997.

Reference Book

1. I. Goodfellow, Y. Bengio and A. Courville. Deep Learning. MIT Press, 2016.
2. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press, 2018.
3. M. P. Deisenroth, A. A. Faisal, C. S. Ong, Mathematics for Machine Learning, Cambridge University Press (1st edition), 2020.
4. S. Haykin. Neural networks and learning machines. Pearson 2008.
5. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
6. K. Murphy. Machine Learning: A probabilistic perspective, MIT Press, 2012.
7. Hastie, Tibshirani, Friedman, Elements of statistical learning, Springer, 2011.

Semester	**IV**
Subject Code	**21AD43**
Subject Title	**Database Management Systems**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course objective is to present a rudimentary level foundations in database management systems concepts with an emphasization on how to organize data efficiently and retrieve them

Course Outcome

CO1: Knowledge in basic concepts and the architecture of database management systems, data models, relational database theory and the features of ER Model.

CO2: Ability to apply relational algebra operations and write appropriate SQL queries with suitable constraints for a given database application

CO3: Master the sound design principles of relational database design using normalization concepts.

CO4: Ability to use different Database Storage structures, access techniques and Indexing methods in Database applications.

CO5: Knowledge in transaction processing concepts, Concurrency Control mechanism and Database Recovery methods and the ability to apply the concepts in the design of Database applications.

INTRODUCTION

Purpose of DBMS - Applications - Views of data - Data Abstraction - Instances and Schemas – Data Models - Database Design - Relational Databases - Database Architecture - Database users and administrators - History of Database systems. Entity- Relationship (E-R) Model: Basic concepts - Constraints - E-R Diagram - Weak Entity Sets - Reduction of Relational schemas. **(9)**

RELATIONAL MODEL

Structure of Relational Databases - Relational Algebra Fundamentals - Introduction to SQL: Basic Structure - Set operations - Aggregate functions - Nested Sub queries - Complex queries – Join Expressions-Views - Modification of the database - Integrity constraints - Referential Integrity - Triggers – Assertions- Formal Relational Query Languages: The Tuple Relational Calculus- The Domain Relational Calculus **(9)**

DATABASE DESIGN

Features of good relational design - Atomic domains and First Normal Form - Decomposition using Functional Dependencies - Functional Dependency theory - Normalization using Functional Dependencies - Decomposition using Multi-valued Dependencies. **(9)**

STORAGE

RAID-File Organization- Organization of Records in Files- Data-Dictionary Storage-Indexing and Hashing: Basic concepts, Ordered Indices: Dense and Sparse Indices - MultiLevel Indices - Index Update. B+-Tree Index Files: Structure of a B+-Tree - Queries in B+-Trees. Static Hashing, Dynamic Hashing.

(9)

TRANSACTION MANAGEMENT

Transaction Concepts and States - Concurrent Executions - Serializability. Concurrency control: Lock Based Protocols: Locks, Granting of Locks, 2-phase locking protocol - Timestamp Based Protocols - Validation based protocols - Deadlock Handling. Recovery Systems: Failure classification - Log based Recovery - Recovery with concurrent Transactions. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Abraham Silberschatz, Henry F.Korth, S.Sudharshan,"Database System Concepts", McGraw-Hill, Seventh Edition, 2019.

Reference Book

1. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Pearson Education, Seventh Edition, 2015.
2. Raghu Ramakrishnan, Johannes Gehrke, "Database Management Systems", McGraw Hill Education, Third Edition, 2014.
3. Peter Rob, CorlosM.Coronel, "Database Systems: Design, Implementation and Management," Thompson Learning Course Technology, Tenth edition, 2012.
4. Thomas M.Connolly and Carolyn E.Begg, "A Practical Approach to Design, Implementation and Management", Pearson, 6th Edition, 2014.

Semester	**IV**
Subject Code	**21AD44**
Subject Title	**Principles of Computer Systems**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course objective is to provide an understanding on the design, functions and modules of hardware and operating systems

Course Outcome

CO1: Outline the basic functionalities of operating systems, operating system components, various types of operating system and system software.

CO2: Understanding of various process synchronization techniques.

CO3: Knowledge in various memory management schemes.

CO4: Understand I/O management and File systems.

CO5: Understand the difference between microprocessor and micro controller

COMPUTER SYSTEM OVERVIEW

Introduction to system software - Objectives and functions of OS - Evolution of OS - Distributed system - Real-Time systems - Operating system components - Interrupts -System call - Virtual machines - Symmetric Multiprocessing - Microkernel. **(9)**

PROCESS DESCRIPTION AND CONTROL

Process - Process states - Process description - Process control -Processes and Threads Uniprocessor Scheduling: Types of Processor Scheduling - Scheduling Algorithms: FCFS, SPN, SRT, Round Robin, Priority, Multi-Level Queue, Multi-level Feedback, Fair Share - Overview of Multiprocessor Scheduling and Real time scheduling- Principles of concurrency - Mutual exclusion- Semaphores – Monitors- Deadlock and Starvation: Principles of deadlock - Deadlock Prevention - Deadlock Detection - Deadlock Avoidance. **(9)**

MEMORY MANAGEMENT

Memory management requirements - Memory partitioning - Loading and Linking - Paging - Segmentation. Virtual Memory: Hardware and control structures – Virtual Memory Management Policies: Fetch Policy, Placement policy, Replacement policy- Resident set management - Cleaning policy - Load control.

(9)

I/O MANAGEMENT AND FILE MANAGEMENT

I/O devices - Organization of I/O function - OS design issues - I/O buffering - Disk scheduling. File management: Overview - File organization and access - File directories - File sharing - Record blocking-Secondary storage management.

(9)

MICROPROCESSOR and MICROCONTROLLER

Operating system concepts behind microprocessors and microcontrollers- High performance RISC architecture- Fundamentals of ARM processor - Registers, Current Program Status Register, Pipeline, Exceptions, Interrupts- Core extensions – ARM processor families- Microcontroller Architecture

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. William Stallings, "Operating Systems Internals and Design Principles", Pearson Education, 9th Edition, 2018.
2. R. S. Gaonkar, “Microprocessor Architecture: Programming and Applications with the 8085/8080A”, Penram International Publishing, Third Edition, 1996.

Reference Book

1. Silberchatz, Galvin, Gagne, "Operating System Concepts", John Wiley, 10th Edition, 2018.
2. Dhananjay M. Dhamdhere, “Operating System a Concept Based Approach”, McGraw Hill Publication, 3rd Edition, 2017.
3. David A. Patterson and John L Hennessy, “Computer Organization and Design, The Hardware/Software Interface”, 2014
4. A.K.Ray and K.M.Bhurchandi, “Advanced Microprocessors and Peripherals”,Tata McGrawHill,2000.

Semester	**IV**
Subject Code	**21AD45**
Subject Title	**Data Communication and Networking**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of the course is to make the students understand the fundamentals of computer networking and understand the working principle of various communication protocols. The course also aims to introduce basics of wireless communication.

Course Outcome

CO1: To outline the basics of signals, the media, computer networks, and its layered architecture.

CO2: To learn the error control, flow control mechanism and the medium access control.

CO3: To understand the working of the network layer, addressing, framing and routing of packets.

CO4: To analyse the principles of Transport layer and its protocols.

CO5: To know the working of upper layer protocols like Telnet, E-Mail etc.

PHYSICAL LAYER

Introduction - Network Models – Protocol Layering – Layers in the OSI Model – TCP/IP Protocol Suite – Addressing – Data and Signals: Analog and Digital Signals – Periodic Analog Signals – Digital Signals – Transmission Impairment – Data Rate Limits – Performance –Bandwidth Utilization: Frequency Division Multiplexing –Time Division Multiplexing – Spread Spectrum - Transmission Media: Guided Media – Unguided Media

(9)

DATA LINK YEAR

Introduction – Link Layer Addressing – Error Detection and Correction - Introduction – Block Coding – Cyclic Codes: Cyclic Redundancy Check – Checksum – Forward Error Correction: Using Hamming Distance – Using XOR – DLC Services - Simple Protocol – Stop and Wait – Piggybacking – HDLC – PPP – MAC – Random Access – Controlled access – Channelization – Ethernet – Standard Ethernet IEEE 802.3 - Connecting Devices

(9)

NETWORK LAYER
Introduction to Network Layer – Network Layer Services – Packet Switching – Performance -IPV4 Addresses – Forwarding of IP Packets – Network Layer Protocols – IP - ICMPV4 – Unicast Routing – Introduction – Routing Algorithms – Unicast Routing Protocols – RIP - OSPF – Multicasting – Introduction – Multicasting Basics – Next Generation IP – IPV6 Addressing – IPV6 Protocol – Transition from IPV4 to IPV6 **(9)**
TRANSPORT LAYER
Introduction – Transport Layer Protocols- Stop-and-Wait Protocol - Go-Back-N Protocol - Selective-Repeat Protocol - Bidirectional Protocols: Piggybacking – UDP –User Datagram - UDP Services - UDP Applications - TCP - TCP Services – TCP Features – Segment - A TCP Connection - State Transition Diagram - Windows in TCP - Flow Control - Error Control - TCP Congestion Control - TCP Timers **(9)**
APPLICATION LAYER AND WIRELESS TECHNOLOGIES
World Wide Web and HTTP – FTP – Electronic Mail – Telnet – Secure Shell - Domain Name System- Wiresless Technologies: Wireless LAN- Wireless WAN: GSM, CDMA, WCDMA, HSPA, LTE- 4G/5G technologies **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Behrouz A Forouzan, "Data Communication & Networks", McGraw Hill, 5th Edition, 2013.
2. William Stallings, "Data & Computer Communications", Prentice Hall, 8th Edition, 2008.

Reference Book

1. Iti Saha Misra, "Wireless Communications and Networks 3G and Beyond", 2 nd Edition, McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2016.
2. Anwer Al-Dulaimi, Xianbin Wang and Chih-Lin I, "5G Networks: Fundamental Requirements, Enabling Technologies, and Operations Management", Wiley-IEEE Press, London, 2018.
3. Martin Sauter, "3G, 4G and Beyond: Bringing Networks, Devices and the Wen Together", 2 nd Edition, John Wiley & Sons, United Kingdom, 2013.
4. Kurose and Ross, “Computer Networking - a top-down approach”, 6th Edition, Pearson Education, 2017.
5. L. L. Peterson and B. S. Davie, “Computer Networks - a systems approach”, 5th Edition, Morgan Kaufman, 2011.

Semester	**IV**
Subject Code	**21AD46**
Subject Title	**Foundation in Data Science**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	Assume knowledge in Mathematics and Basic Programming
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to provide conceptual and practical understanding on the field of data science by relating to real world applications. It provides the learners to explore the fundamental concepts, key techniques, tools in various context of data science.

Course Outcome

CO1: Be able to understand the data science Lifecyle and Pre-processing

CO2: Be able to understand the descriptive data analytics

CO3: Be able to understand the concepts of inferential data analytics and variance a

CO4: Be able to evaluate formulas, create charts and use tools for data analytics and visualization.

CO5: Be able to design predictive models from data

FUNDAMENTALS IN DATA SCIENCE

Data science in real world - Need for data science – benefits and uses – facets of data – data science process – setting the research goal – retrieving data – cleansing, integrating, and transforming data – exploratory data analysis – build the models – presenting and building applications **(9)**

DESCRIPTIVE ANALYTICS

Frequency distributions –Interpreting distributions – Graphs for Quantitative Data- describing variability – Variability for qualitative and ranked data - Normal distributions and Z scores –Correlation – Scatter plots – Regression – Interpretation of r^2 – Multiple regression – Regression toward the mean. **(9)**

INFERENTIAL STATISTICS

Populations – samples – random sampling – Sampling distribution- Hypothesis testing– Estimation – point estimate **(9)**

VARIANCE ANALYSIS	
T-test for one sample – sampling distribution of t – t-test procedure – t-test for two independent samples – p-value – statistical significance – t-test for two related samples– Introduction to chi-square tests **(9)**	
PREDICTIVE ANALYTICS	
Linear least squares –Regression using StatsModels – Multiple regression –Logistic regression –Time series analysis –Introduction to survival analysis. **(9)**	
TOTAL: 45	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. David Cielen, Arno D. B. Meysman, and Mohamed Ali, "Introducing Data Science", Manning Publications, 2016
2. I.A.Dhote, " Fundamentals of Data Science and Anaytics", Technical Publication, 2022

Reference Book

1. Foreman, J.W, "Data Smart: Using Data Science to Transform Information into Insight", John Wiley & Sons, 2013.
2. O'Neil, C. & Schutt, "R. Doing Data Science", O'Reilly Media Inc, 2014.
3. Emc Expert team, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", EMC Education Services, John Wiley & Sons, 2015.
4. Sanjeev J. Wagh, Manisha S. Bhende, Anuradha D. Thakare, "Fundamentals of Data Science", CRC Press, 2022.

<table>
<tr><td>Semester</td><td>IV</td></tr>
<tr><td>Subject Code</td><td>21ADL47</td></tr>
<tr><td>Subject Title</td><td>Machine Learning Laboratory</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21FYM21 - Linear Algebra and Gradient Calculus
21AD31 – Probability and Statistics
21CSL22 – Python Programming</td></tr>
<tr><td>Credit Points</td><td>1.5 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>3</td><td>1.5</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Practicals</td></tr>
<tr><td>Course Objective</td><td>To provide familiarization of the concepts of machine learning philosophies and prepare students for research or industry application of machine learning techniques.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: Demonstrate various supervised learning paradigms for real-time data sets.
CO2: To possess and insight in the working philosophies of ML approaches.
CO3: Be able to design and implement various machine learning algorithms in a range of real-world applications.
CO4: Experiment with large number of datasets for unsupervised algorithms
CO5: To experiment and evaluate machine learning algorithms for different problem domain</td></tr>
<tr><td colspan="2">Introduction</td></tr>
<tr><td colspan="2">Implementation of FIND S Algorithm to find the most specific hypothesis based on a given set of training data samples.
Implementation of Candidate-Elimination algorithm
Linear Regression, Logistic Regression algorithmic implementation
Support Vector Machines implementation
Working philosophy of the decision tree based ID3 algorithm
Building Artificial Neural Network – Backpropagation algorithm
Experiments based on Naïve Bayesian Classifiers
Clustering datasets – EM, k-Means and k-Nearest neighbour algorithms
Fitting Data points – Locally weighted Regression algorithm</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.
Software : Python **Date Sets for deploying the Problem sets :** https://archive.ics.uci.edu/ml/index.php	

Semester	**IV**
Subject Code	**21ADL48**
Subject Title	**Database Management Systems Laboratory**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	Assume knowledge in Mathematics and Basic Programming
Credit Points	1.5 CP
Learning and Teaching Structure	L T P C 0 0 3 1.5
Assessment Type	Practicals
Course Objective	The objective of this lab course is to understand the practical applicability of DBMS concepts. Working on existing DB systems, designing of database, creating relational database and analysis of table design.

Course Outcome

CO1: Practice various DDL, DML, TCL commands so as to perform various database operations and solve queries for given application.

CO2: Demonstrate open database connectivity by establishing connections between front end and databases

CO3: Experiment various PL/SQL features such as procedures, functions, triggers and report generation.

EXPERIMENTS USING THE FOLLOWING CONCEPTS

1. Database Creation, Insertion and Deletion.
2. Queries based on DML commands.
3. Aggregate Functions.
4. Sub-Queries and Joins.
5. Group by clause and DATE functions.
6. Views and Triggers.
7. PL/SQL Procedures.
8. Using Cursors and Functions in PL/SQL blocks.
9. Study of Open Source NOSQL Database
10. ODBC Connectivity.

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Software Required: Oracle SQL plus

Semester	**V**
Subject Code	**21AD51**
Subject Title	**Cloud Architecture**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD35 – Web Development Technologies 21AD46 – Foundation in Data Science
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The Course's aim is to introduce the Cloud Architecture, services, its applications and the relevant technologies. It will provide the students basic understanding about cloud, virtualization and MapReduce programming.

Course Outcome

CO1: To understand the fundamental principles of distributed and cloud computing.

CO2: To perceive the importance of virtualization and to gain an in-depth knowledge of virtualization in cloud computing.

CO3: To explore the MapReduce Programming model extensively.

CO4: To shed light on the security issues in cloud computing.

CO5: To expose the students to the frontier areas of cloud computing.

OVERVIEW OF CLOUD COMPUTING

History of Centralized and Distributed Computing - Overview of Distributed Computing, Cluster computing and Grid computing. Definition of Cloud Computing - Public, Private and Hybrid Clouds – Iaas, PaaS and Saas –Benefits and Challenges of cloud computing. **(9)**

VIRTUALIZATION

Understanding Virtualization - Virtualization - Moore's Law - Importance of Virtualization - Virtualization and Cloud Computing - Virtualization of Software Operation - Virtualizing Servers, Desktops and Applications, Hypervisors: Type 1 and Type 2 Hypervisors - Virtual Machines: Overview - Examining CPUs, Memory, Network Resources and Storage in Virtual Machines - Working of a VM - Working with a VM - Clones - Templates - Snapshots - OVF - Containers - CPU Virtualization: Hyper-Threading - Understanding Memory Virtualization - Understanding Storage Virtualization- Understanding Network Virtualization **(9)**

PROGRAMMING MODEL

Map Reduce: A Weather Dataset - Analyzing the Data with Unix Tools and Hadoop- Scaling Out - Hadoop Streaming - Hadoop Pipes - Developing Map Reduce Applications: The Configuration API - Configuring the Development Environment - Writing a Unit Test with MRunit - Running Locally on Test Data and on a Cluster - MapReduce Workflows. Basics of Scala. **(9)**

CLOUD SECURITY

Cloud Security Fundamentals: Cloud Information Security Objectives - Confidentiality, Integrity, and Availability - Cloud Security Services -Authentication - Authorization - Auditing - Accountability - Cloud Computing Security Architecture: Architectural Considerations - Compliance - Security Management - Information Classification - Trusted Cloud Computing - Trusted Computing Characteristics - Secure Execution Environments and Communications - Identity Management and Access Control.

(9)

EDGE CLOUD COMPUTING & CASE STUDIES

Introduction to Edge & Fog Computing- Technologies - Fog and Edge Computing Completing the Cloud- Hierarchy of Fog and Edge Computing - Case Studies - Google App Engine, Amazon AWS, Microsoft Azure

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
2. Mathew Portnoy, "Virtualization Essentials", Wiley India Pvt Ltd, New Delhi, 2017.

Reference Book

1. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012.
2. Krutz, Ronald L, and Russell Dean Vines, “Cloud security: A comprehensive guide to secure cloud computing”, Wiley Publishing, 2010.
3. Rajkumar Buyya and Satish Narayana Srirama, “Fog and Edge Computing: Principles and Paradigms” Wiley, USA, 2019.
4. Alex Payne, Dean Wampler “Programming Scala= Functional Programming + Objects: ”, O’Reilly publication, 3rd edition, 2014
5. Rajkumar Buyya, Christian Vecchiola, and ThamaraiSelvi, “Mastering Cloud Computing”, Tata McGraw Hill, 2013.

Semester	**V**
Subject Code	**21AD52**
Subject Title	**Mobile Application Development**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	Assume knowledge in Basic Programming
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The main objective of this Flutter Course is to guide an individual to learn flutter from scratch. This course will make the students familiar to flutter programming language. The course aims at making the student install the framework, IDE, to start developing and will have an understanding of the use of Google's Dart language to quickly prototype a mobile app.

Course Outcome

CO1: To learn DART language for mobile app development with Flutter

CO2: To understand the basics of app development, creation of Widgets and Layouts for the app

CO3: To know how to bring in interactivity and navigation to an app

CO4: To comprehend the need for and the methods of Asynchronous programming in Flutter

CO5: To learn Firebase and method of adding animations to the app

DART, WIDGETS AND LAYOUTS

Variables - Strings and String Interpolation - Write Functions - Using Functions as Variables with Closures - Creating Classes and using the Class Constructor Shorthand - Grouping and Manipulation of Data with Collections - Less Code with Higher Order-Functions - Taking Advantage of the Cascade Operator - Dart Null Safety - Requirements - Immutable Widgets - Using a Scaffold - Using Container Widget - Printing Stylish Text on Screen - Importing Fonts and Images into the APP

(9)

INTERACTIVITY, NAVIGATION TO APP AND STATE MANAGEMENT

Adding the State to App - Interacting with Buttons - Making it Scroll - Handling Large Datasets with List Builders - Working with TextFields - Navigating to the Next Screen - Invoking Navigating Routes by Name - Showing Dialogs on the Screen - Showing Dialogs on the Screen - Presenting Bottom Sheets - Model - View Separation - Managing the Data Layer with InheritedWidget - Making the App state Visible across Multiple Screens - Designing an n-tier architecture - Controllers, Repositories and Services **(9)**

ASYNCHRONOUS PROGRAMMING

Technical Requirements - Using async/await to remove callbacks - Completing Futures - Firing Multiple Futures at the Same time - Resolving errors in asynchronous code - Using Futures with StatefulWidgets - Using FutureBuilder - Turning Navigation Routes into Asynchronous Functions - Getting the Results from a Dialog - Data Persistence and Communicating with the Internet Technical Requirements: Converting Dart Models into JSON - Handling JSON Schemas - Catching Common JSON Errors - Saving Data with SharedPreferences - Accessing FileSystem - Designing Http Client and getting Data - POSTing Data **(9)**

ADDING ANIMATIONS TO THE APP

Creating Basic Container Animations - Designing animations using the Animation Controller - Adding Multiple Animations - Using Curves - Optimizing Animations - Using Hero Animations - Using Premade Animation Transition - Using the Animated List Widget - Implementing Swiping with the Dismissible Widget - Using the Animations Flutter Package **(9)**

FIREBASE

Using Firebase: Configuring a Firebase App - Creating a Login Form - Adding Google Sign-in - Integrating Firebase Analytics **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book.

1. Alessandria Simone and Kayfitz Brian, “Flutter Cookbook: Over 100 Proven Techniques and Solutions for App Development with Flutter 2.2 and Dart”, United Kingdom, Packt Publishing, 2021.

Reference Book

1. Napoli Marco L, “Beginning Flutter: A Hands On Guide to App Development”, United States, Wiley, 2019.
2. Clow Mark, “Learn Google Flutter Fast: 65 Example Apps. Poland”, Independently Published, 2019.
3. Biessek Alessandro, “Flutter for Beginners: An Introductory Guide to Building Cross-platform Mobile Applications with Flutter and Dart 2”, United Kingdom, Packt Publishing, 2019.

Semester	**V**
Subject Code	**21AD53**
Subject Title	**Data Mining and Analysis**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD43 – Database Management Systems 21AD46 – Foundation in Data Science
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of this course is to introduce the fundamental processes of data warehousing and data mining. To impart the knowledge on various data mining concepts and techniques that can be applied to text mining, web mining etc.

Course Outcome

CO1: To understand the fundamentals of data, its attributes and its visualization.

CO2: To learn to prepare the data needed for data mining using various preprocessing techniques.

CO3: To discover interesting patterns from large amounts of data using Association Rule Mining.

CO4: To learn the multiple Classification techniques used for data mining.

CO5: To gain an understanding of the various Clustering techniques.

INTRODUCTION

Data Objects and Attribute Types: Introduction to Data Types - Nominal Attributes - Binary Attributes - Ordinal Attributes - Numeric Attributes - Discrete vs Continuous Attributes - Basic Statistical Descriptions of Data: Measuring the Central Tendency - Measuring the Dispersion of Data - Graphic Displays of Description of Data - Data Visualization- Measuring Data Similarity. **(9)**

DATA PREPROCESSING

Overview of Data Pre-processing: Data Quality - Major Tasks in Data Preprocessing - Data Cleaning: Missing Values - Noisy Data - Data Cleaning as a Process - Data Integration: Entity Identification Problem - Redundancy and Correlation Analysis - Tuple Duplication Data Reduction: Overview - Wavelet Transforms - Principal Components Analysis - Attribute Subset Selection - Regression and Log-Linear Models - Histograms - Clustering - Sampling - Data Cube Aggregation - Data Transformation and Data Discretization. **(9)**

DATA WAREHOUSING AND ONLINE ANALYTICAL PROCESSING

Data Warehouse: Differences between Operational Database Systems and Data Warehouses - Need for a Separate Data Warehouse - Data Warehousing: A Multitiered Architecture - Data Warehouse Models - Extraction, Transformation, and Loading - Metadata Repository - Data Warehouse Modeling: Data Cube and OLAP - Data Warehouse Design and Usage: Framework - Design Process - Usage - From Online Analytical Processing to Multidimensional Data Mining . **(9)**

MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS

Basic Concepts: Market Basket Analysis - Frequent Itemset, Closed Itemsets and Association Rules - Frequent Itemset Mining Methods: Apriori Algorithm - Generating Association Rules - Improving Efficiency of Apriori - A Pattern-Growth Approach for Mining Frequent Itemsets - Mining Frequent Itemsets Using Vertical Data Format **(9)**

CLASSIFICATION AND CLUSTERING

Basic Concepts - Decision Tree Induction: Decision Tree Induction - Attribute Selection Measures - Tree Pruning - Scalability and Decision Tree Induction - Visual Mining for Decision Tree Induction - Bayes Classification Methods: Baye's Theorem - Naive Bayesian Classification - Rule-Based Classification - Model Evaluation and Selection: Metrics for Evaluating Classifier Performance - Cross-Validation – Bootstrap – Clustering - Introduction to Cluster Analysis: Requirements for Cluster Analysis - Overview of Basic Clustering Methods - Partitioning Methods: k-Means - k-Medoids - Hierarchical Methods: Agglomerative versus Divisive Hierarchical Clustering **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Jiawei Han and Micheline Kamber, Jian Pei, "Data Mining Concepts and Techniques", Morgan Kaufman Publications, Third Edition, 2011.
2. Ian H.Witten and Eibe Frank "Data Mining – Practical Machine Learning Tools and Techniques", Morgan Kaufman Publications, Third Edition, 2011.

Reference Books

1. David Hand, Heikki Mannila and Padhraic Smyth, “Principles of Data Mining”, MIT PRESS, 2001.
2. Jure Leskovec, Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, Second Edition, 2014.
3. Pang Ning Tan, Michael Steinbach and Vipin Kumar, "Introduction to Data Mining", Pearson Education, Noida, 2016.
4. Mohammed J. Zaki and Wagner Meira, "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge India, New Delhi, 2016.

Semester	**V**
Subject Code	**21AD54**
Subject Title	**Big Data Architecture: Tools and Techniques**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course aims at giving an overview of BigData Architecture, its storage, retrieval and the processing of data. It also focuses on the tools, techniques and algorithms available for storing and processing of Big Data.

Course Outcome

CO1: To explore the fundamental concepts of big data and to understand the environment and difference between Business Intelligence and Big Data.
CO2: To comprehend Data analytics and tools available for them.
CO3: To gain an understanding of the Hadoop and MangoDB ecosystem.
CO4: To understand MapReduce Programming and Cassandra
CO5: To gain an in-depth understanding of Hive, Pig and real-life big data applications.

INTRODUCTION TO BIG DATA

Classification of Digital Data - Characteristics of Data - Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3 Vs of Big Data : Volume, Velocity, Variety - Why Big Data - Business Intelligence vs Big Data - Data Warehouse Environment - Hadoop Environment **(9)**

BIG DATA ANALYTICS AND BIG DATA TECHNOLOGY

Beginning of Big Data - Introduction to Big Data Analytics - Classification of Analytics - Challenges Preventing Businesses from Capitalizing on Big Data - Challenges Facing Big Data - Importance of Big Data Analytics - Technologies that Help Meet the Challenges - Data Science and Data Scientist - Terminologies in Big Data Environment - BASE - NoSQL **(9)**

HADOOP AND MONGODB

Introduction to Hadoop - RDBMS vs Hadoop - Distributed Computing Challenges - History of Hadoop - Hadoop Overview - Use Case of Hadoop - Hadoop Distribution - HDFS - Processing Data with Hadoop - Managing Resources with Hadoop YARN - Interacting with Hadoop Ecosystem - Introduction to MongoDB - Terms in RDBMS and MongoDB - MongoDB Data Types - MongoDB QueryLanguage **(9)**

CASSANDRA AND MAPREDUCE PROGRAMMING

Introduction to Apache Cassandra - Cassandra Features - CQL Datatypes - CQLSH - Keyspaces - CRUD - Collections - Counter - TTL - Alter Commands - Import and Export - Querying System Tables - Introduction to MAPREDUCE Programming - Mapper - Reducer - Combiner - Partitioner - Searching - Sorting - Compression **(9)**

HIVE PIG AND SPARK

Introduction to Hive - Hive History - Hive Features - Hive Integration - Hive Data Units - Hive Architecture - Hive Data Types - Hive File Format - Hive Query Language - Introduction to Pig - Features of Pig - Pig Anatomy - Pig on Hadoop – Basics of SPARK – Features of SPARK – Usage of SPARK

(9)

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Acharya S and Chellappan S, “Big data and analytics”, Wiley, 2015.

Reference Books

1. EMC Education Services, “Data science and big data analytics: discovering, analyzing, visualizing and presenting data”. Wiley, 2015.
2. Tom White, "Hadoop: The Definitive Guide", 4th Edition, O‘Reilly, USA, 2015
3. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley,USA, 2014.
4. Bill Chambers, Matei Zaharia, “Spark: The Definitive Guide”, O'Reilly, 2018

<table>
<tr><td>Semester</td><td>V</td></tr>
<tr><td>Subject Code</td><td>21ADL55</td></tr>
<tr><td>Subject Title</td><td>Mobile Application Development Laboratory</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>30 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>Assume knowledge in Basic Programming</td></tr>
<tr><td>Credit Points</td><td>1 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>2</td><td>1</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Practicals</td></tr>
<tr><td>Course Objective</td><td>The subject aims to design and develop mobile application using Flutter</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To be able to setup flutter development environment and program with DART
CO2: To be able to design widgets and layouts for an app.
CO3: To be able to design user interfaces for app interaction
CO4: To be able to add navigation for app
CO5: To be able to deploy the mobile application</td></tr>
<tr><td colspan="2">LIST OF EXPERIMENTS BASED ON THE FOLLOWING CONCEPTS</td></tr>
<tr><td colspan="2">1. Build mobile application, activities, testing, debugging and using support libraries
2. User Interface Screen elements, designing User Interfaces with layouts, drawing and working with animation, Testing UI
3. Working with background tasks, triggering, scheduling and optimizing background tasks
4. Storing data using SQLite, sharing data with content providers, loading data using loaders
5. Adding animations, Firebase and AdMob, Publish the app
6. Basics of Android Programming</td></tr>
<tr><td>Minimum Requirement to pass the subject</td><td>To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.</td></tr>
<tr><td colspan="2">SOFWARE REQUIRED: Based on Course Instructor’s prescription</td></tr>
</table>

Semester	**V**
Subject Code	**21ADL56**
Subject Title	**Data Mining and Analysis Laboratory**
Duration	One Semester
Total Contact Hours	30 Hours per semester
Pre-Requisite	21AD43 – Database Management Systems 21AD46 – Foundation in Data Science
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	To provide an understanding of computational approaches to Data Modelling and be acquainted with the tools and techniques used for Knowledge Discovery in Databases.

Course Outcome

CO1: To gain knowledge in the usage of Data Mining tools.
CO2: To learn the fundamentals of data mining process and to know about data cleaning, pre-processing and integration.
CO3: To implement and evaluate the principal algorithms and techniques used in data mining, such as clustering, association mining, classification and prediction.
CO4: To apply data mining techniques and methods to large data sets.
CO5: To able to apply mining techniques for realistic data.

LIST OF EXPERIMENTS

1. Creation of a Data Warehouse
2. Apriori Algorithm
3. FP-Growth Algorithm
4. K-means clustering
5. Hierarchical Clustering algorithm
6. Bayesian Classification
7. Decision Tree
8. Support Vector Machines
9. Applications of classification for Web Mining
10. Case Study on Text Mining or any commercial application

Software Required: WEKA, RapidMiner, DB Miner or Equivalent

Semester	**V**
Subject Code	**21ADOC03**
Subject Title	**Comprehensive Exam Training**
Duration	One Semester
Total Contact Hours	15 Hours per semester
Pre-Requisite	N/A
Credit Points	1 CP
Learning and Teaching Structure	L T P C - - - 1
Assessment Type	Theory
Course Objective	This is a preparatory course to demonstrate mastery of knowledge in a few substantive areas of computer science and engineering and Data Science

Course Outcome

CO1: To able to revisit the fundamentals of computer science AI and Data Science.

CO2: To be able to pursue well in the competitive exams

C PROGRAMMING	
Programming in C, Recursion, Arrays, Structures and Pointers	**(3)**
DATA STRUCTURES AND ALGORITHMS	
Linked Lists, Stacks, Queues, Trees, Graphs, Sorting and Searching	**(2)**
DIGITAL DESIGN	
Boolean algebra, Combinational and Sequential circuits, Minimization, Number representations, Fixed and floating point computer arithmetic	**(2)**
DATABASE MANAGEMENT SYSTEMS	
ER-model, Relational model: relational algebra, tuple calculus, SQL, Integrity constraints, Normal forms, B+ tree indexing, Transactions and concurrency control	**(2)**
COMPUTER ARCHITECTURE	
Machine instructions and Addressing modes, ALU, Data-path and Control unit, Instruction pipelining, Pipeline hazards, Memory hierarchy: cache, main memory and secondary storage, I/O interface: interrupt and DMA mode	**(2)**
OPERATING SYSTEMS	
System calls, Processes, Threads, Deadlock, CPU and Disk scheduling, Memory management and Virtual memory	**(2)**

FORMAL LANGUAGES AND AUTOMATA THEORY	
Regular Expressions and Finite Automata, Context-Free Grammars and Push-Down Automata, Context-Free Languages, Pumping lemma, Turing machines **(2)**	
TOTAL: 15	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Reference Books

1. Relevant text books of the prescribed topics.

<table>
<tr><td>Semester</td><td>VI</td></tr>
<tr><td>Subject Code</td><td>21AD61</td></tr>
<tr><td>Subject Title</td><td>Deep Learning Techniques</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21FYM21 – Linear Algebra and Gradient Calculus
21AD31 – Probability and Statistics
21AD42 – Machine Learning Techniques
Proficiency in Python</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The objective of this course is to iintroduce major deep learning algorithms, the problem settings, and their applications to solve real world problems. In this course, students will learn the fundamentals of deep learning, and the main research activities in this field. Moreover, students will learn to implement, train, and validate their own neural network.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To understand the context of neural networks and deep learning.
CO2: To analyze Convolution Neural Networks
CO3: To learn the working of Recurrent Neural Networks
CO4: To explore concepts of Autoencoders, Representation Learning and Unsupervised Training
CO5: To learn to use Deep Generative Models and explore few real time applications of Deep Learning</td></tr>
<tr><td colspan="2">INTRODUCTION TO DEEP LEARNING</td></tr>
<tr><td colspan="2">Introduction to Neural Networks - Deep Networks - Deep Forward Networks: Learning XOR - Gradient Based Learning - Hidden Units - Architecture Design - Back-Propagation - Other Differentiation Algorithms - Regularization for Deep Learning: Parameter Norm Penalties - Norm Penalties as Constrained Optimization - Regularization and Under-Constrained</td></tr>
</table>

Problems - Dataset Augmentation - Noise Robustness - Semi-Supervised Learning - Multi-Task Learning - Early Stopping - Parameter Tying and Parameter Sharing - Sparse Representations - Bagging and Other Ensemble Methods - Dropout - Adversarial Training - Tangent Distance, Tangent Prop, and Manifold Tangent Classifier - Optimization for Training Deep Models: Learning vs Pure Optimization - Challenges in Neural Network Optimization - Basic Algorithms - Parameter Initialization Strategies - Algorithms with Adaptive Learning Rates - Approximate Second-Order Methods - Optimization Strategies and Meta-Algorithms **(9)**

CONVOLUTION NETWORKS

The Convolution Operation - Motivation - Pooling - Convolution and Pooling as an Infinitely Strong Prior - Variants of the Basic Convolution Function - Structured Outputs - Data Types - Efficient Convolution Algorithms .Random or Unsupervised Features - The Neuroscientific Basis for Convolutional Networks - Convolutional Networks and the History of Deep **(9)**

SEQUENCE MODELING

Recurrent Neural Networks: Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures - Deep Recurrent Networks - Recursive Neural Networks - The Challenge of Long-Term Dependencies - Echo State Networks - Strategies for Multiple Time Scales - The Long Short-Term Memory and Gated RNNs - Optimization for Long-Term Dependencies - Explicit Memory **(9)**

AUTOENCODERS AND REPRESENTATION LEARNING

AutoEncoders: Undercomplete Autoencoders - Regularized Autoencoders - Representational Power, Layer Size and Depth - Stochastic Encoders and Decoders - Denoising Autoencoders - Learning Manifolds with Autoencoders - Contractive Autoencoders - Predictive Sparse Decomposition - Applications of Autoencoders - Representation Learning - – Transfer Learning and Domain Adaptation – Applications**.** **(9)**

DEEP GENERATIVE MODELS

Deep Generative Models: Boltzmann Machines - Restricted Boltzmann Machines - Deep Belief Networks - Deep Boltzmann Machines - Boltzmann Machines for Real-Valued Data - Convolutional Boltzmann Machines - Boltzmann Machines for Structured or Sequential Outputs - Other Boltzmann Machines - Back-Propagation through Random Operations - Directed Generative Nets - Drawing Samples from Autoencoders - Generative Stochastic Networks - Generation Schemes - Evaluating Generative Models -Applications **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016.
2. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127.

Reference Book

1. N.D.Lewis, "Deep Learning Made Easy with R: A Gentle Introduction for Data Science", 2016.
2. Nikhil Buduma, "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms", O'Reilly publications, 2017.
3. Tariq Rashid, "Make your own neural network ", 2017.
4. Yann LeCun, Yoshua Bengio & Geoffrey Hinton, "Deep learning", Nature,Vol: 521, pp: 436 – 444.

<table>
<tr><td>Semester</td><td>VI</td></tr>
<tr><td>Subject Code</td><td>21AD62</td></tr>
<tr><td>Subject Title</td><td>Computer Vision & Pattern Recognition</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21AD32 - Data structure and algorithms
21AD33 - Artificial Intelligence
21AD42 - Machine Learning Techniques</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The objective of this course is to introduce to students the fundamentals of image formation; to introduce students the major ideas, methods, and techniques of computer vision and pattern recognition; to develop an appreciation for various issues in the design of computer vision and object recognition systems.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To understand the fundamentals of Image Processing.
CO2: To identify the different filtering approaches in image processing.
CO3: To learn the basics of edge detection and thresholding in image.
CO4: To know the foundations of pattern recognition.
CO5: To analyze the various statistical classification methods.</td></tr>
<tr><td colspan="2">FUNDAMENTALS OF IMAGE PROCESSING</td></tr>
<tr><td colspan="2">Fundamental steps in image processing - Image acquisitions: Image acquisition using a single sensor - Acquisition using a sensor strip - Acquisition using Sensor Arrays - Simple Image Formation Model - Image Sampling and Quantization: Basics - Representing Digital Images - Spatial and Intensity Resolution - Image Interpolation - Intensity Transformations and Spatial Filtering: Basics - Intensity Transformation Functions - Histogram Processing - Fundamentals of Spatial Filtering - Smoothing Spatial Filters - Sharpening Spatial Filters - Fuzzy Techniques for Spatial Filtering (9)</td></tr>
<tr><td colspan="2">IMAGE RESTORATION</td></tr>
</table>

A Model of the Image Degradation/Restoration Process - Noise Models - Restoration in the Presence of Noise Only - Spatial Filtering - Periodic Noise Reduction by Frequency domain filtering - Inverse Filtering - Minimum Mean Square Error (Wiener) Filtering - Constrained Least Squares Filtering - Geometric Mean Filter - Image Reconstruction from Projections. **(9)**

IMAGE SEGMENTATION

Fundamentals of Image Segmentation - Point, Line, and Edge Detection: Detection of Isolated Points - Line Detection - Edge Models - Basic Edge Detection – Thresholding: Foundation - Global Thresholding - Optimum Global Thresholding - Image Smoothing - Using Edges to Improve Global Thresholding - Multiple Thresholds - Variable Thresholding - Region-Based Segmentation - Segmentation Using Morphological Watersheds - The Use of Motion in Segmentation **(9)**

PATTERN RECOGNITION

Machine Perception - Pattern Recognition Systems: Sensing - Segmentation and Grouping - Feature Extraction - Classification -Post Processing - The Design Cycle: Data Collection - Feature Choice - Model Choice - Training - Evaluation - Computational Complexity - Learning and Adaptation: Supervised Learning - Unsupervised Learning - Reinforcement Learning **(9)**

STATISTICAL PATTERN RECOGNITION

Bayesian Decision Theory: Two Category Classification - Minimum Error Rate Classification – Classifiers, Discriminant Functions and Decision Surfaces - Normal density: Univariate Density - Multivariate Density - Discriminant functions for the Normal Density - Parameter estimation methods: Maximum-Likelihood estimation - Bayesian parameter estimation - Dimensionality: Principal Component Analysis (PCA) - Fisher Linear discriminant analysis - Expectation-maximization (EM) - Hidden Markov Models (HMM): First- Order Markov Models - First- Order Hidden Markov Models - Gaussian mixture model **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Ganzalez and Wood, “Digital Image Processing “, 4th edition, Pearson, 2017
2. R.O. Duda, P.E. Hart , D.G. Stork, “Pattern Classification “, Second Edition John Wiley, 2006

Reference Book

1. Anil K.Jain, “Fundamental of Image Processing”, Prentice Hall of India, 1988
2. Abhishek Yadav, Poonam Yadav, “Digital Image Processing”, Laxmi Publication, 2009.
3. Gibson, Willi, Putnam Adult, “Pattern Recognition” , 2003
4. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2009.
5. S. Theodoridis and K. Koutroumbas, “Pattern Recognition”, 4th Edition, Academic Press,2009

Semester	**VI**
Subject Code	**21AD63**
Subject Title	**Data Visualization**
Duration	**One Semester**
Total Contact Hours	45 hours per semester
Pre-Requisite	21AD46 - Foundation in Data Science
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to provide knowledge on fundamental principles and different types of data visualization techniques. It also examines the types of information graphics and visual presentation for different types of applications.

Course Outcome

CO1: To perceive the need for data visualization and explore data and task abstraction

CO2: To introduce methods to design effective visualizations

CO3: To understand the visual representations of spatial and non-spatial data

CO4: To gain an understanding of color theory and manipulation and changing views

CO5: To explore representation methods and techniques that increase the understanding of complex data

FUNDAMENTALS OF VISUALIZATION

The Big Picture - Having a Human in the Loop - Computer in the Loop - Using an External Representation - Dependence on Vision - Showing Data in Detail - Using Interactivity - Visualization Design Space - Focus on Tasks - Focus on Tasks - Focus on Effectiveness - Design Ineffectiveness - Difficulty in Validation - Resource Limitations - Importance of Analyzing - Vision Concepts of Visualization - Data Abstraction: Data Semantics - Data Types - Dataset Types - Attribute Types - Semantics - Task Abstraction: Abstract Task Analysis - Designer vs User - Actions - Targets - Task Abstraction, A Preview - Examples of Analyzing and Deriving **(9)**

VISUALIZATION ANALYSIS
Four level of validation: The Big Picture - Importance of Validation - Four Levels of Design - Angles of Attack - Threats to Validity - Validation Approaches - Validation Examples - Marks and channels: The Big Picture - Importance of Marks and Channels - Defining Marks and Channels - Using Marks and Channels - Channel Effectiveness - Relative versus Absolute Judgements - Rules of Thumb: The Big Picture - Following Rules of Thumb - No Unjustified 3D - No Unjustified 2D - Eyes Beat Memory - Resolution over Immersion - Overview First, Zoom and Filter, Details on Demand - Responsiveness is Required - Getting it Right in Black and White - Function First and Form Next **(9)**
TABLES, SPATIAL DATA, NETWORKS AND TREES
Arrange Tables: The Big Picture - Importance of Arrangement - Arrange by Keys and Values - Expressing Quantitative Values - Separate, Order and Align - Spatial Axis Orientation - Spatial Layout Density - Arrange Spatial Data: The Big Picture - Using Given - Geometry - Scalar Fields - Vector Fields - Tensor Fields - Arrange Network and Trees: The Big Picture - Connection: Link Marks - Matrix Views - Costs and Benefits: Connection versus Matrix - Containment: Hierarchy Marks **(9)**
MAP COLORS
Map Colors: The Big Picture - Color Theory: Color Vision - Color Spaces - Luminance, Saturation and Hue - Transparency - Colormaps: Categorical Colormaps - Ordered Colormaps - Bivariate Colormaps - Colorblind-safe Colormap Design - Other Channels: Size Channels - Angle Channel - Curvature Channel - Shape Channel - Motion Channels - Texture and Stippling - Manipulate View - The Big Picture - Reason for Change - Change View over Time - Select Examples - Navigate: Changing Viewpoint - Navigate: Reducing Attributes - Facet into manipulate view: The Big Picture - Importance of Facet - Juxtapose and Coordinate views - Partition into Views - Superimpose Layers **(9)**
VISUALIZATION REPRESENTATION
Reduce items and attributes: The Big Picture - Importance of Reduce - Filter - Aggregate - Embed:Focus and context: The Big Picture - Reason for Embed - Elide - Superimpose - Distort - Analysis case studies: The Big Picture - Analyzing Case Studies - Graph Theoretic Scagnostics - VisDB - Hierarchical Clustering Explorer - PivotGraph - InterRing – Constellation **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Tamara Munzner, “Visualization Analysis and Design” , First Edition, CRC Press, 2014

Reference Book

1. E. Tufte, “The Visual Display of Quantitative Information”, 2nd Edition, Graphics Press, 2001
2. Sosulski, K, “Data Visualization Made Simple: Insights into Becoming Visual”, Routledge, 2018
3. Scott Murray, Interactive Data Visualization for the Web, O’Reilly, 2013

<table>
<tr><td>Semester</td><td>VI</td></tr>
<tr><td>Subject Code</td><td>21ADL64</td></tr>
<tr><td>Subject Title</td><td>Deep Learning Laboratory</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>60 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21FYM21 – Linear Algebra and Gradient Calculus
21AD31 – Probability and Statistics
21AD42 – Machine Learning Techniques
Proficiency in Python</td></tr>
<tr><td>Credit Points</td><td>2 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>4</td><td>2</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Practicals</td></tr>
<tr><td>Course Objective</td><td>The objective of this course is to learn deep learning algorithms, concepts, experiments, research along with their application on generic use cases.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To understand the basics concepts of deep learning.
CO2: To emphasizing knowledge on various deep learning algorithms.
CO3: To understand CNN and RNN to model real world applications.
CO4: To understanding the various challenges involved in designing deep learning algorithms for varied applications.
CO5: To identify and apply Deep Learning algorithms to solve real world problems.</td></tr>
<tr><td colspan="2">Required Software : Tensorflow, Pytorch, Theano, Keras and Scikit-learn</td></tr>
<tr><td colspan="2">Artificial Neural Networks to solve a Customer Churn problem
Convolutional Neural Networks for Image Recognition
Recurrent Neural Networks to predict Stock Prices
Self-Organizing Maps to investigate Fraud
Boltzmann Machines to create a Recommender System
Stacked Autoencoders</td></tr>
<tr><td>Minimum Requirement to pass the subject</td><td>50</td></tr>
</table>

Semester	**VI**
Subject Code	**21ADL65**
Subject Title	**Data Visualization Laboratory**
Duration	One Semester
Total Contact Hours	30 hours per semester
Pre-Requisite	21AD46 - Foundation in Data Science
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	The subject aims to provide a practical session of visual analytics using data visualization tools-tableau

Course Outcome

CO1: To be able to understand the core concepts of data visualization using Tableau
CO2: To be able to create ad-hoc reports using Tableau
CO3: To be able to create data visualizations using Tableau
CO4: To be able to create dashboards using Tableau
CO5: To be able to create and import data into Tableau tool and understand the relationship between data analytics and visualization.

LIST OF EXPERIMENTS

1. Introduction to Tableau
2. Communicating Data
3. Ratio and rates
4. Proportion and percentages
5. Mean and Median
6. Variation and Uncertainty
7. Multiple Quantities
8. Maps and location
9. Dashboards
10. Advanced dashboard features

Software Required: Tableau and other supporting software as per Course Instructor's prescription

<table>
<tr><td>Semester</td><td>VI</td></tr>
<tr><td>Subject Code</td><td>21AD66</td></tr>
<tr><td>Subject Title</td><td>Mini Project</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>90 hours per semester</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>6</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Practicals</td></tr>
<tr><td>Course Objective</td><td>This subject is project based in which students work on solving one or more challenges specifically designed and focused towards technology. The aim of the mini project is to work on second phase of testing and deployment stages and deliver the final product.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To be able to apply computing algorithms and techniques in designing simple solutions.
CO2: To be able to analyse and examine the outcome of real- time projects.
CO3: To integrate various interdisciplinary areas to enhance domain knowledge.
CO4: To develop technical skills in providing feasible solutions for real-life problems and enhance technical writing ability.
CO5: To be able to demonstrate effective communication and collaborative working in peer groups.</td></tr>
<tr><td colspan="2">LIST OF EXPERIMENTS</td></tr>
<tr><td colspan="2">1. Refining project requirements
2. Implementation
3. Designing, writing, compiling, documenting, and testing programs
4. Software deployment
5. Project Management
6. Technical writing</td></tr>
<tr><td>Minimum Requirement to pass the subject</td><td>To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the subject of 50% or more.</td></tr>
<tr><td>Text Book</td><td>NIL</td></tr>
<tr><td>Reference Book</td><td>NIL</td></tr>
</table>

<table>
<tr><td>Semester</td><td>VII</td></tr>
<tr><td>Subject Code</td><td>21AD71</td></tr>
<tr><td>Subject Title</td><td>Data Security</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>NIL</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The subject aims to provide an understanding of basics components of Cryptography and Network Security. It also covers how Confidentiality, Integrity and Availability of a data is ensured. It also gives an understanding of various protocols for network security to protect against the threats in the networks.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To comprehend the major security requirements, threats and vulnerability of information systems and fundamental cryptographic techniques.
CO2: To learn in detail the technology behind user authentication and preserving the integrity of data.
CO3: To perceive the need for Information Security and gain knowledge on the principles and methods involved in securing sensitive information.
CO4: To understand the vulnerabilities in Databases and to explore the technology behind Database security.
CO5: To explore and understand the fundamentals of Differential Privacy.</td></tr>
<tr><td colspan="2">BASICS OF COMPUTER SECURITY</td></tr>
<tr><td colspan="2">Computer Security Concepts - The OSI Security Architecture - Security Attacks - Security Services - Security Mechanisms - Security Design Principles - Attack Surfaces and Attack Trees - Standards (9)</td></tr>
<tr><td colspan="2">CRYPTOGRAPHY</td></tr>
</table>

Symmetric Ciphers: Classical Encryption Techniques - Block Ciphers and the Data Encryption Standard - Advanced Encryption Standard -Block Cipher Operation: Multiple Encryption and Triple DES - Random bit Generation and Stream Ciphers: Pseudo Random Number Generation using a Block Cipher - Stream Ciphers - RC4 - Asymmetric Ciphers - Public Key Cryptography and RSA - RSA Algorithm - Elliptic Curve Cryptography **(9)**
MESSAGE INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT
Key Management - Symmetric Key Distribution using Symmetric and Asymmetric Encryption - Diffie Hellman Key Exchange - Cryptographic Hash Functions - Applications - Two Simple Hash Functions - Requirements and Security - Hash Functions Based on Cipher Block Chaining - SHA - MAC - Requirements and Functions of MACs - HMAC - CMAC - Digital Signatures: Elgamal Digital Signature -User Authentication - Kerberos - Electronic Mail Security: Pretty Good Privacy - S/MIME **(9)**
INFORMATION SECURITY
Need for Information Security: Threats and Attacks - Compromises to Intellectual Property - Deviations in Quality of Service - Espionage - Human Error - Information Extortion - Vandalism - Hardware Failures - Software Failures - Risk Management: Overview - Risk Identification - Risk Assessment - Risk Control - Planning for Security - Information Security Policy, Standards and Practices - Continuity Strategies - Security Technology: Access Control - Firewalls - Protecting Remote Connections - Intrusion Detection and Prevention Systems **(9)**
DATABASE SECURITY AND DIFFERENTIAL PRIVACY
Importance of Database Security- Security Objectives - Hackers- Social Engineers - Computer Users - Network and Database Administrators - Internet - Misleading Applications - E-mails - Instant Messages - Tweets - Malware - Security Architecture - Global Policies - Passwords, Profiles, Privileges and Roles: Authentication - Authorization - Inference - SQL Injection 1: Identification - SQL Injection Exploitation and Defense - Object Level Security - Security Auditing - Introduction to Differential Privacy - Global Sensitivity - Local Sensitivity - Differentially Private Data Publishing **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. William Stallings, "Cryptography and Network Security: Principles and Practice", 8th Edition,Prentice Hall of India, Pearson Education, New Delhi , 2020.
2. Whitman M, "Principles of Information Security", 5th edition, Cengage, 2015.

Reference Book

1. Basta, Alfred, and Melissa Zgola. "Database Security". Cengage Learning, 2011.
2. TianqingZhu, GangLi, WanleiZhou, Philip S. Yu, "Differential Privacy and Applications", Springer, 2017.
3. Hans Delfs, Helmut Knell, "Introduction to Cryptography: Principles and Applications", Springer , 2007.
4. Wenliang Du, "Computer & Internet Security: A Hands-on Approach" , 2019.

<table>
<tr><td>Semester</td><td>VII</td></tr>
<tr><td>Subject Code</td><td>21AD72</td></tr>
<tr><td>Subject Title</td><td>IoT and its Applications</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21CS21 -Digital Design
21FYM21 – Linear Algebra and Gradient Calculus</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The objective of the course is to impart the know-how of Internet of Things, their applications, architectures and protocols, building IoT applications/systems, securing the IoT systems, and their recent advances.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To understand the fundamentals and applications of IoT.
CO2: To gain knowledge in a variety of IOT protocols
CO3: To attain proficiency in the working principles of Physical devices viz., Arduino and Raspberry Pi.
CO4: To attain the ability to apply Data Analytics for IoT.
CO5: Understand the real-world applications for IoT.</td></tr>
<tr><td colspan="2">IoT ARCHITECHURE</td></tr>
<tr><td colspan="2">Genesis of IoT - Impact of IoT - IoT Challenges - IoT Network Architecture and Design - The one M2M - IoT World Forum and Alternative IoT Models - Simplified IoT Architecture - Core IoT Functional Stack - Fog, Edge and Cloud in IoT - Fundamental Blocks of Iot - Sensors, Actuators, MEMS - Wireless Sensor Networks (9)</td></tr>
<tr><td colspan="2">IoT PROTOCOLS</td></tr>
<tr><td colspan="2">Connecting Smart Objects - Communication Criteria - IoT Access Technologies - IEEE 802.15.4 - IEEE 1901.2a - LoRaWAN -Bluetooth - Zigbee - GSM - IP the IOT Network Layer: Key Advantage of Internet Protocol - Adoption or Adaptation of Internet Protocol -</td></tr>
</table>

Need for Optimization: Constrained Nodes - Constrained Networks - IP Versions - Optimizing IP for IoT - From 6LoWPAN to 6Lo - Header Compression - Fragmentation - Mesh Addressing - Mesh Under versus Mesh - over Routing - Application Protocols for IoT - SCADA - CoAP - MQTT **(9)**

PROGRAMMING THE MICROCONTROLLER FOR IoT

Electronics - Sensors - Actuators - Scaling up the Electronics - Embedded Computing Basics - Microcontrollers - System on Chips - Choosing Platform - Arduino: Developing on the Arduino - Notes on Hardware - Openness- Raspberry Pi: Cases and Extension Records - Developing on the Raspberry Pi - Notes on Hardware - Openness - Techniques for Writing Embedded Code: Memory Management - Performance and Battery Life - Libraries - Debugging – Introduction to Contiki OS **(9)**

DATA ANALYTICS AND IOT

Data Analytics for IOT: Introduction to Structured vs Unstructured Data - Data in Motion vs Data at Rest - IoT Data Analytics: Overview - Big Data Analytics Tools and Technology: Massively Parallel Processing Databases - IoT Data Analytics Challenges - No SQL Databases - Hadoop Ecosystem - Apache Kafka - Apache Spark - Edge Streaming Analytics - Network Analytics - Xively Cloud for IoT - Python Web Application Framework - Django - AWS for IoT **(9)**

Enterprise IoT and APPLICATIONS

Enterprise IoT- IoT Use cases: Smart city, Home Automation, Smart health and wearable devices, Environment monitoring and surveillance, Smart Agriculture

(**9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, and Jerome Henry, “IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things”, Cisco Press, 2017.
2. Arshdeep Bahga and Vijay Madisetti, “Internet of Things – A hands on approach”, Universities Press, 2017.

REFERENCE BOOKS

1. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, Wiely , 2015
2. Simone Cirani, Gianluigi Ferrari, Marco Picone and Luca Veltri. “Internet of Things: Architectures, Protocols and Standards”, 1 st edition, Wiley Publications, 2019.
3. J.P Vasseur and A. Dunkels, “Interconnecting Smart Objects with IP: The next Internet”, Morgan Kufmann, 2010.
4. Contiki: The opensource for IOT, www.contiki-os.org
5. Charalampos Doukas, “Building Internet of Things with Arduino”, Create space, April 2002.

<table>
<tr><td>Semester</td><td>VII</td></tr>
<tr><td>Subject Code</td><td>21AD73</td></tr>
<tr><td>Subject Title</td><td>Applied Natural Language Processing</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21AD41 – Discrete Mathematics and Automata Theory
21AD33 – Principles of Artificial Intelligence</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>To gain knowledge in the fundamental aspects of Natural Language Processing(NLP) viz., Syntactic Structures and their associated Semantic meanings. To imbibe knowledge in pragmatics of NLP techniques in Knowledge Inference.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To have an in-depth understanding of the mathematics behind language processing.
CO2: To comprehend the syntax analysis and parsing that is essential for natural language processing
CO3: To learn about the various representations of semantics and discourse in terms of NLP.
CO4: To be able to design NLP-based AI systems for text summarization.
CO5: To have knowledge about the applications of natural language processing.</td></tr>
<tr><td colspan="2">BASICS OF NLP</td></tr>
<tr><td colspan="2">Introduction - Mathematical Foundations - Natural language processing techniques - The different analysis levels used for NLP: morpho-lexical - syntactic – semantic - pragmatic - markup (TEI, UNICODE) – Applications – open problems. (9)</td></tr>
<tr><td colspan="2">WORDS</td></tr>
</table>

Linguistic Essentials - Regular Expressions, Text normalization, Edit Distance – Finite State Transducers - N Gram Language Models - Naive Bayes and Sentiment Classification - Neural Networks and Neural Language Models - Hidden Markov Model (HMM) Part of Speech Tagging **(9)**

SYNTAX

Grammar Rules for English -Syntactic/Constituency Parsing- Ambiguity - CKY Parsing - Probabilistic Context Free Grammars - Probability of a String - Using Inside Outside Probabilities - Dependency Parsing - Transition-Based Dependency Parsing - Graph-Based Dependency Parsing. **(9)**

SEMANTICS

Vector Semantics - Semantics with Dense Vectors - Word Senses and WordNet - WSD and WordNet - Lexicons for Sentiment, Affect, and Connotation - Logical Representations of Sentence Meaning - Computational Semantics and Semantic Parsing - Information Extraction - Named Entity Recognition - Semantic Role Labeling - Coreference Resolution - Entity Linking (**9)**

PRAGMATICS AND NLP APPLICATIONS

Discourse Coherence - Discourse Coherence – Neural Sequence modeling: RNN, LSTM – Text Summarization - Question Answering- Applications: Translation involving Indian Languages - Report Generation - Natural Language Generation in Information Visualization, Education, and Healthcare- Chatbots **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Daniel Jurafsky and James H. Martin, “Speech and Language Processing”, Prentice-Hall, Inc., 2017.
2. Christopher D Manning and Hinrich Schütze, “Foundations of Statistical Natural Language Processing”, The MITPress, 2018.

Reference Books

1. Nitin Indurkhya and Fred J Damerau, “Handbook of Natural Language Processing”, 2nd Edition, Chapman and Hall/CRC Press, 2010.
2. Yoav Goldberg, “Neural Network Methods for Natural Language Processing”, Synthesis Lectures on Human Language Technologies, April 2017.
3. Li Deng and Yang Liu, "Deep Learning in Natural Language Processing", Springer, Germany. 2018.
4. Steven Bird, Ewan Klein, and Edward Loper, “Natural Language Processing with Python - Analyzing Text with the Natural Language Toolkit”, O,Reilly. 2019
5. Jalaj Thanaki, “Python Natural Language Processing - Advanced machine learning and deep learning techniques for natural language processing, Packt Publisher, 2017.

Semester	**VII**
Subject Code	**21ADL74**
Subject Title	**Applied Natural Language Processing Laboratory**
Duration	One Semester
Total Contact Hours	30 hours per semester
Pre-Requisite	21AD41 – Discrete Mathematics and Automata Theory 21AD33 – Principles of Artificial Intelligence
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	The subject aims to provide a practical session on dealing with concepts of computer science, artificial intelligence and linguistics. The lab will cover the basics of NLP using NLP tools to solve the practical problems.

Course Outcome

CO1: To design algorithms and write programs for enabling machines to perform human language-related tasks.
CO2: To develop speech-based applications that use speech analysis.
CO3: To extract information from text automatically using concepts and methods from natural language processing.
CO4: To write programs using NLP methods to analyse sentiment of a text document
CO5: To gain practical experience with NLP toolkits and interpret the results

LIST OF EXPERIMENTS

1. Word analysis
2. Word generation
3. Morphology
4. N-Grams
5. Syntactic parsing
6. Sematic Analysis
7. Machine translation
8. Information Extraction
9. Natural language extraction
10. Hands-on exercise on NLP tools

Software Required: NLP tools and other supporting software as per Course Instructor's prescription

Semester	**VII**
Subject Code	**21ADL75**
Subject Title	**Internet of Things Laboratory**
Duration	One Semester
Total Contact Hours	30 hours per semester
Pre-Requisite	21CS21 - Digital Design 21FYM21 – Linear Algebra and Gradient Calculus
Credit Points	1 CP
Learning and Teaching Structure	L T P C 0 0 2 1
Assessment Type	Practicals
Course Objective	The subject aims to gain practical experience on developing IoT-based solutions using IoT sensors and device.

Course Outcome

CO1: To be able to use micro controller-based platforms such as Arduino/Raspberry Pi
CO2: To be able to use the popular IoT sensors, gateways and management of data
CO3: To be able to identify techniques and tools of sensing and computation to solve multi-disciplinary challenges.
CO4: To be able to develop and integrate the cloud and webserver with IoT applications
CO5: To be able to develop and test IoT solutions on different IoT platform and software's

LIST OF EXPERIMENTS

1. Work with Raspberry Pi Platform, Linux commands and python programming
2. Different sensors interfaced with Raspberry Pi
3. Work with Arduino platform
4. Sensors interfaced with Arduino
5. Arduino interfaced with ZigBee Module
6. Arduino interfaced with GSM and GPS Module
7. Arduino interfaced with Bluetooth and WiFi Module
8. Communication between Raspberry PI and Arduino
9. Cloud platform, API, Web servers for IoT applications
10. MQQT protocol

Hardware and Software Required: Arduino Uno/ Raspberry Pi/ Sensors (temperature, Humidity/ moisture/ Ultrasound/LED) and other supporting software as per Course Instructor's prescription

<table>
<tr><td>Subject Code</td><td>21AD76</td></tr>
<tr><td>Subject Title</td><td>Project Phase-I</td></tr>
<tr><td>Duration</td><td>90 Hours</td></tr>
<tr><td>Pre-Requisite</td><td>N/A</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>6</td><td>3</td></tr></table></td></tr>
<tr><td>Course Objective</td><td>To enhance students' problem-solving abilities and technical proficiency by designing and implementing a project in the field of Artificial Intelligence and Data Science, bridging theoretical concepts with practical applications.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To analyse real world problems and develop solutions, which are practical and effective utilising appropriate AI tools, techniques and methods.
CO2: To enhance the critical thinking and problem solving abilities by tackling complex AI challenges and developing innovative solutions
CO3: To apply software engineering methodology and development tools to the analysis design, implementation, testing of AI based applications to meet user requirements.
CO4: To integrate knowledge from various disciplines, demonstrating an ability to apply interdisciplinary approaches to their work.
CO5: To demonstrate professional behaviours through effective leadership, writing reports, teamwork and communication skills.</td></tr>
</table>

<table>
<tr><td>Subject Code</td><td>21AD81</td></tr>
<tr><td>Subject Title</td><td>Project Phase-II</td></tr>
<tr><td>Duration</td><td>150 Hours</td></tr>
<tr><td>Pre-Requisite</td><td>N/A</td></tr>
<tr><td>Credit Points</td><td>5 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>0</td><td>0</td><td>10</td><td>5</td></tr></table></td></tr>
<tr><td>Course Objective</td><td>To improve students' problem-solving skills and technical expertise through the design and implementation of a project in Artificial Intelligence and Data Science, connecting theoretical knowledge with practical application.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To identify real-world issues and create practical, effective solutions using suitable AI tools, techniques, and methods.

CO2: To apply critical thinking and problem-solving skills by addressing intricate AI challenges and developing creative solutions.

CO3: To utilize software engineering practices and development tools in the analysis, design, implementation, and testing of AI applications that fulfill user needs.

CO4: To show the ability to employ interdisciplinary approaches in their work by combining knowledge from various fields.

CO5: To demonstrate professional conduct through effective leadership, report writing, teamwork, and communication skills.</td></tr>
</table>

	Professional Elective
Subject Code	**21ADE01**
Subject Title	**User Interface Design**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The goal of user interface design is to make the student to learn to design the user's interaction as simple and efficient as possible, in terms of accomplishing user goals (user-centric design).

Course Outcome

CO1: To gain a solid foundation in Graphics Interface characteristics and its principles

CO2: To understand the user interface design process and the fundamental components of the interfaces

CO3: To design Human computer interaction standards and structures

CO4: To perceive the importance of multimedia in user interface design and its creation

CO5: To summarize the concepts of windows layout and visualization

CONCEPTS OF USER INTERFACE DESIGN

Introduction to the User Interface: Defining the User Interface - The importance and the Benefits of good Design - History of the Human Computer Interface - Characteristics of Graphical and Web User Interfaces: The Graphical User Interface - The Web User Interface - The Merging of Graphical Business Systems an the Web - Principles of User Interface Design **(9)**

HUMAN COMPUTER INTERACTION

User Interface Design Process – Obstacles and Pitfalls in the Development Path – Usability – The Design team - Understanding People Computer Interaction - Human Characteristics In Design – Human Considerations in Design - Human Interaction Speed – Understanding Business Functions: Business Definition and Requirement Analysis - Determining Business Functions – Design Standards or Style Guides - System training and Documentation Needs - Principles of Good Screen Design: Human Consideration In Screen Design – Structures Of Menus – Functions Of Menus – Contents Of Menu– Formatting – Phrasing The Menu – Selecting Menu Choice – Navigating Menus– Graphical Menus. **(9)**

WINDOWS

Characteristics – Components – Presentation Styles – Types – Managements – Organizations – Operations – Web Systems – Device Based Controls Characteristics – Screen Based Controls – Operate Control – Text Boxes – Selection Control – Combination Control– Custom Control – Presentation Control. **(9)**

MULTIMEDIA

Text For Web Pages – Effective Feedback – Guidance & Assistance – Internationalization – Accessibility – Icons – Image– Multimedia – Colouring. **(9)**

WINDOWS LAYOUT

Prototypes – Kinds Of Tests – Developing and Conducting the test - Retest – Information Search – Visualization – Software Tools. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Wilbent. O. Galitz, “The Essential Guide to User Interface Design”, John Wiley& Sons, 2001.
2. Ben Sheiderman, “Design the User Interface”, Pearson Education, 1998.

Reference Book

1. Alan Cooper, “The Essential of User Interface Design”, Wiley – Dream Tech Ltd., 2002.

	Professional Electives
Subject Code	**21ADE02**
Subject Title	**Design and Analysis of Algorithms**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD32- Data Structures and Algorithms
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective is to teach techniques for effective problem solving in computing. The use of different paradigms of problem solving will be used to illustrate efficient ways to solve a given problem statement. In addition, the analysis of the algorithm will be used to show the efficiency of the algorithm over the naive techniques.

Course Outcome

CO1: To understand the basics of Algorithms and to learn how to estimate their worst case and average case behavior.
CO2: To learn in-detail Greedy method of solving problems
CO3: To gain expertise in Divide and Conquer methods, Graph traversals and their analyses.
CO4: To learn how Dynamic Programming approaches works for various problems.
CO5: To become familiar with NP-Completeness and polynomial time reduction.

BASICS OF ALGORITHMS

Fundamentals of Algorithmic Problem Solving: Understanding the Problem - Algorithmic Design Techniques - Designing an Algorithm and Data Structures - Methods of Specifying an Algorithm - Proving the Algorithm's Correctness - Analyzing an Algorithm - Problem Types: Sorting - Searching - String Processing - Graph Problems - Combinatorial Problems - Geometric and Numeric Problems - Fundamental Data Structures - Analysis Framework - Asymptotic Notations and Basic Efficiency Classes

(9)

GREEDY METHOD
Activity Selection Problem - Elements of Greed Strategy - Huffman Codes - Matroids - Prim's Algorithm - Kruskal Algorithm - Dijkstra's Algorithm **(9)**
DIVIDE AND CONQUER
Merge Sort - Quick Sort -Strassen's Matrix Multiplication - Binary Tree Traversals - Substitution Method - Recursion tree Method - Master Method **(9)**
DYNAMIC PROGRAMMING
The Knapsack Problem and Memory Functions - Optimal Binary Search Trees - Matrix Chain Multiplication - Longest Common Subsequence - Warshall's Algorithm - Floyd's Algorithm for the All Pair Shortest Paths Problem **(9)**
BACKTRACKING AND NP- COMPLETNESS
The General Method - The 8 Queens Problem - Sum of Subsets - Graph Coloring - Hamiltonian Cycles - Knapsack Problem -NP- Completeness: Polynomial Time- Verification-Completeness abd Reducablity **(9)**
TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Anany Levitin, "Introduction to the Design and Analysis of Algorithms", 3rd Edition, Prentice Hall of India, New Delhi, 2017.
2. Thomas H Cormen, Leiserson, Rivest, and Stein, "Introduction to Algorithms", MIT Press, Third Edition, 2009.

Reference Books

1. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran , "Fundamentals of Computer Algorithms", Galgotia Publications, New Delhi, 2010.
2. Dasgupta, Papadimitrou and Vazirani, "Algorithms", McGraw-Hill Education, 2006.
3. Kleinberg and Tardos, "Algorithm Design", Pearson Education, 2005.
4. Goodrich and Tamassia, "Algorithm Design", Wiley publications, 2001.

	Professional Electives
Subject Code	**21ADE03**
Subject Title	**Information Retrieval**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course explores the fundamentals of information retrieval. It discusses implementation and evaluation issues of new algorithms like clustering, pattern searching and stemming with advanced data/file structures.

Course Outcomes

CO1: To understand the foundations of information retrieval namely Boolean retrieval and vector space model.

CO2: To design methods to build indexes.

CO3: To understand relevance feedback in vector space model and probabilistic model.

CO4: To comprehend the principles of probabilistic information retrieval.

CO5: To learn the implementation of clustering algorithms like hierarchical clustering and k-means algorithms.

Fundamentals of Information Retrieval

Basics of Information Retrieval - Introduction to Search Engines-Boolean Retrieval-: Boolean queries, Building simple indexes, Processing Boolean queries-Term Vocabulary and Posting Lists-Choosing document units-Determining the vocabulary of terms -Stop word elimination-Stemming and lemmatization-Skip lists, Positional postings and Phrase queries-Dictionaries and Tolerant Retrieval: Data structures for dictionaries, Wildcard queries, Permuterm and K-gram indexes, Spelling correction, Phonetic correction **(9)**

Index construction and vector space modelling

Single pass scheme-Distributed indexing-Map Reduce-Dynamic indexing-Index Compression-Statistical properties of terms-Zipf's law, Heap's law, Dictionary compression, Postings file compression, Variable byte codes, Gamma codes-Vector Space Model- Parametric and zone indexes, Learning weights-Term frequency and weighting-Tf-Idf weighting-Vector space model for scoring, variant tf-idf functions **(9)**

Search and feedback mechanism

Computing Scores in a Complete Search System-Efficient scoring and ranking-Inexact retrieval-Champion lists-Impact ordering-Cluster pruning-Tiered indexes- Query term proximity-Vector space scoring and query operations; Evaluation in Information Retrieval: Standard test collections, unranked retrieval sets, ranked retrieval results, Assessing relevance, User utility, Precision and Recall, Relevance feedback, Rocchio algorithm, Probabilistic relevance feedback, Evaluation of relevance feedback **(9)**

Probabilistic Information Retrieval

Review of basic probability theory-Probability ranking principle-Binary Independence model-Probability estimates-probabilistic approaches to relevance feedback Text Classification-Rocchio classifier, KNearest neighbour classifier, Linear and nonlinear classifiers, Bias-variance tradeoff, Naïve Bayes and Support Vector machine based classifiers. **(9)**

Text Clustering

Clustering in information retrieval-Evaluation of clustering-KMeans and Hierarchical clustering-Introduction to Linear Algebra-Latent Semantic Indexing **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. C D Manning, P Raghavan, and H Schutze, “An Introduction to Information Retrieval”, Cambridge University Press, 2009.

Reference Books

1. R Baeza-Yates and B Ribeiro-Neto, “Modern Information Retrieval”, Pearson Education, 1999.
2. Tanveer Siddiqui and U S Tiwary, “Natural Language Processing and Information Retrieval”, Oxford Univerity Press, 2008
3. Dr. Madhavi Vaidy and Yashowardhan Sowale, “Information Retrieval”, Wiley, 2021

	Professional Electives
Subject Code	**21ADE04**
Subject Title	**Generative AI**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21CSL22- Python Programming 21AD42- Machine Learning Techniques 21AD61 - Deep Learning Techniques
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective is to understand the main learning objectives of this course is to Identify problems where artificial intelligence techniques are applicable. Apply selected basic AI techniques; judge applicability of more advanced techniques.

Course Outcome

CO1: To gain a solid understanding of generative models and also acquire the knowledge on concepts from probability and statistics.

CO2: To explore algorithms used in various approaches like Generative Adversarial Networks (GANs), Variational Auto encoders (VAEs), and autoregressive models.

CO3: To implement and train generative models using popular deep learning frameworks like TensorFlow or PyTorch and recurrent neural networks

CO4: To be proficient in generating synthetic images and text using generative models.

CO5: To explore real-world applications of generative AI and limitations of generative models in various domains.

INTRODUCTION TO GENERATIVE AI

Overview of Generative Al and its significance-Generative vs. Discriminative models-Common applications and use cases of generative models- Probability basics and distributions relevant to generative models-Maximum Likelihood Estimation (MLE) and Maximum a Posteriori (MAP) estimation-Information theory concepts, including entropy and cross-entropy. **(9)**

ENCODERS

Introduction to Auto encoders-Understanding auto encoders and their architecture-Variational Auto encoders (VAEs) and their latent space representations-Applications of auto encoders in image and text data. **(9)**

INTRODUCTION TO GENERATIVE ADVERSARIAL NETWORKS (GANS)

The concept of GANS and how they work-Training GANS: Generator and Discriminator networks-Mode collapse and other challenges in GANS- Deep Convolutional GANS (DCGANs)-Architectural improvements for GANS, particularly for image generation-Using DCGANs for generating realistic images-Applying DCGANS in computer vision tasks. **(9)**

RECURRENT NEURAL NETWORKS (RNNS)

Overview of RNNs and sequence-to-sequence models-Training RNNs for text and music generation-Challenges in long-term sequence generation- Introduction to Transformers-Understanding the transformer architecture-Applications of transformers in NLP and generative tasks. **(9)**

AI IN REAL-WORLD APPLICATIONS

Style transfer and image-to-image translation-Text-to-image synthesis-GANS for drug discovery and molecule generation-Directions in Generative AI Cutting-Edge research and breakthroughs in the field-Open problems and challenges in generative AI **(9)**

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books:

1. "Talking About Generative AI",by Sidney I.Dobrin,Version 1.0,publised May 15,2023.
2. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville: This comprehensive book covers a wide range of deep learning topics, including generative models like variational auto encoders (VAEs) and generative adversarial networks (GANs). Though it may not specifically focus on GPT-3, it provides a solid foundation in deep learning techniques that underlie many generative models.
3. "Natural Language Processing with PyTorch" by Delip Rao and Brian McMahan: This book covers natural language processing (NLP) techniques using the PyTorch framework, which is relevant for building and understanding generative language models.
4. "Neural Networks and Deep Learning: A Textbook" by Charu Aggarwal: This book is a comprehensive introduction to neural networks and deep learning techniques, which are the backbone of many generative models.

5. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto: While not directly focused on generative models, this book covers reinforcement learning, which is an essential component in many advanced generative AI systems.
6. "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig: This classic AI textbook provides a broad overview of artificial intelligence, including topics related to generative models.
7. Generative Deep Learning" by David Foster: This book focuses specifically on generative models, such as autoencoders, generative adversarial networks (GANs), and variational autoencoders (VAEs).
8. "Generative Modeling" by Michael I. Jordan: This book provides an in-depth overview of generative models and their applications in various domains.
9. Hands-On Generative Adversarial Networks with PyTorch" by Ashish Singh Bhatia and Rajalingappaa Shanmugamani: While more specialized in GANs, this book provides practical hands-on guidance for implementing generative models using PyTorch.
10. "Grokking Deep Learning" by Andrew W. Trask: This book offers a beginner-friendly approach to understanding deep learning concepts and can serve as a good starting point for those new to generative models and AI.

<table>
<tr><td></td><td>Professional Electives</td></tr>
<tr><td>Subject Code</td><td>21ADE05</td></tr>
<tr><td>Subject Title</td><td>Agile Software Development</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>NIL</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The course is aimed at understanding the core beliefs of Agile and Scrum. This course teaches the principles and practices that make Agile and Scrum effective at managing projects. The course reviews the principles of Scrum, XP, and the activities to support the training process.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To comprehend the underlying philosophy and principles of Agile
CO2: To learn the lifecycle of an Agile project
CO3: To be able to learn the different types of agile practices for software development and to gain exposure on how to apply agile framework in process of software development
CO4: To explore the concepts of scrum and extreme programming
CO5: To be able to learn the strategic business drivers and benefits of applying agile methods in software industry</td></tr>
<tr><td colspan="2">AGILE MANAGEMENT</td></tr>
<tr><td colspan="2">Theories for Agile management - Management Accounting for Systems - TOC in Software Production - Dealing with Uncertainty - Software Production Metrics - Agile Project Management (9)</td></tr>
</table>

AGILE DEVELOPMENT MANAGEMENT

Agile Manager's New Work - Agile Development Management - Software resource Planning - An Agile Maturity Model - Setting the Governing Rules - Staffing Decisions - Operations Review **(9)**

AGILE PRODUCT MANAGEMENT

Agile Management in the IT Department - Agile Product Management - Financial Metrics for Software Services - The Business Benefits of Agile Methods - Production Metrics for Traditional Methods - Financial Metrics in Traditional Methods **(9)**

PROJECT MANAGEMENT

Production Metrics in FDD - Project Management with FDD - FDD Process Elements - Financial Metrics in FDD - Production Metrics in Extreme Programming - XP Process Elemets - Financial Metrics in XP **(9)**

SCRUM

Production Metrics in Scrum - Scrum process elements - RAD Process Elements - Devil's Advocacy - States of Control and Reducing Variation - Comparison of Production Metrics - Applicability of Agile Methods **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. David J Anderson and Eli Schragenheim, "Agile Management for Software Engineering: Applying the Theory of Constraints for business Results", Prentice Hall, 2003.

Reference Books

1. Alistair Cockburn, "Agile Software Development", Pearson Education, 2014.
2. Kevin C Desouza, "Agile Information Systems: Conceptualization, Construction, and Management", 1st Edition, 2006.
3. Robert Martin, "Agile Software Development, Principles, Patterns, and Practices", PHI Publication, 2002.

	Professional Electives
Subject Code	**21ADE06**
Subject Title	**Optimization Techniques**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD42 - Machine Learning Techniques 21AD61- Deep Learning Techniques
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of this course is to make the students acquire a systematic understanding of optimization techniques. The course will begin with linear optimization and will discuss in detail the problem formulation and the solution approaches. The course also aims at problem formulation by using linear, dynamic programming and queuing models.

Course Outcome

CO1: To understand the overview of optimization techniques, concepts of design space, constraint surfaces and objective function.

CO2: To solve the Linear Programming models using graphical and simplex methods.

CO3: To formulate real-life transportation, assignment and travelling salesman problems to find the optimum solution using transportation algorithms.

CO4: To understand and analyze the Queuing model.

CO5: To learn to apply dynamic programming to optimize multi stage decision problems.

OVERVIEW OF OPTIMIZATION TECHNIQUES

Statement of an Optimization problem – Design vector – Design constraints – Constraint Surface – Objective Function – Objective Function Surfaces – classification of Optimization problems - Classical Optimization techniques: Single variable Optimization, Multi variable Optimization with and without constraints, Multivariable Optimization with equality constraints - solution by method of Lagrange multipliers, Multivariable Optimization with inequality constraints - Kuhn – Tucker conditions. **(9)**

LINEAR PROGRAMMING

Definitions and Thorems - Solutions of a System of Linear Simultaneous Equations - Reduction of System of Equations - Motivations of Simplex Method - Phase I and Phase II of the Simplex Method - MatLab Solutions - The Revised Simplex method - Primal and Dual Simplex Method **(9)**

TRANSPORTATION PROBLEM

Definition - Non traditional transportation Models - Transportation Algorithm - The Assignment Model - Network Model: Scope and Definition of Network Model - Minimal Spanning Tree Algorithm - Shortest Route Problem - Maximum Flow Model **(9)**

QUEUING AND MARKOV CHAINS

Importance of Queues - Elements of Queuing Model - Exponential Distribution - Pure Birth and Death Models - General Poisson Queuing Model - Specialized Poisson Queues - P-K Formula - Other queuing Models - Queuing Decision Models - Markov Chains: Definition - Absolute and n-step transition Probabilities - Classification of thefcon states in a Markov Chain - Mean Return Times of Ergodic Chains - First passage Time **(9)**

DYNAMIC PROGRAMMING

Dynamic programming multistage decision processes – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution - Integer Linear Programming : Graphical representation - Gomory's Cutting Plane Method - Bala's Algorithm - Integer Nonlinear Programming: Integer Polynomial Programming - Branch and Bound Method - Sequential Linear Discrete Programming - Generalized Penalty Function Method **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Singiresu S Rao, "Engineering optimization: theory and practice" John Wiley & Sons, 2019.
2. Taha Hamdy A, "Operations research: An Introduction", Pearson Educación, 2003.

Reference Books

1. Stephen Boyd and Lieven Vandenberghe, “Convex Optimization”, Cambridge University Press, 2004.
2. Suvrit Sra, Sebestian Nowozin and Stephen J. Wright, “Optimization for Machine Learning”, PHI, 2013.
3. Neal Parikh and Stephen Boyd, Proximal Algorithms, NOW publishers, 2013.

<table>
<tr><td></td><td>Professional Electives</td></tr>
<tr><td>Subject Code</td><td>21ADE07</td></tr>
<tr><td>Subject Title</td><td>Graph Theory in Data Science</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>21AD46 - Foundation in Data Science</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The objective of the course is to present the basic concepts of graph theory, its associated properties (with simplified proofs) and formulations of typical graph problems. This is also supplemented with some abstract-level algorithms for the presented Data Science problem statements.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To gain an in-depth understanding of the foundations of Graph Theory.
CO2: To familiarize with special types of Graphs for modeling and analyzing real-world complex networks.
CO3: To attain the ability to deploy Graph Coloring Techniques to solve topological problems.
CO4: To gain knowledge in solving Combinatorial Optimization and Geometrical problems using Graph Theoretic approaches.
CO5: To relate Graph Theory Algorithms in their respective field of Engineering.</td></tr>
<tr><td colspan="2">FOUNDATIONS OF GRAPHS</td></tr>
<tr><td colspan="2">Foundations: Graphs Definition - Graph as Models - Decomposition and Special Graphs - Paths, Cycles and Trails: Connections in Graphs - Bipartite Graphs - Eulerian Circuits - Vertex Degrees and Counting: Counting and Bijections - Directed Graphs: Definitions and Examples - Vertex Degrees- - Trees and Distances: Properties - Spanning Trees and Enumerations - Optimization and Trees. (9)</td></tr>
</table>

MATCHING AND FACTORS
Matching and Covers: Maximum Matchings - Hall's Matching Condition - Min-Max Theorems - Independent Sets and Covers - Dominating Sets - Algorithms and Applications: Maximum Bipartite Matching - Weighted Bipartite Matching - Stable Matchings - Faster Bipartite Matching - Matching in General Graphs: Tutte's 1 Factor Theorem - *f*-factors of Graphs - Edmonds Blossom Algorithm **(9)**
PATHS CONNECTIVITY AND GRAPH COLORING
Cuts and Connectivity: Connectivity - Blocks - k-Connected Graphs - 2 Connected Graphs - Application of Menger's Theorem - Network Flow Problems - Maximum Network Flow - Graph Coloring: Vertex Coloring and Upper Bound : Definitions and examples - Upper Bounds - Brooke's Theorem - k-chromatic graph structures: Enumerative aspects of Graph Coloring **(9)**
PLANAR GRAPHS AND EDGES
Embeddings and Euler's Formula: Drawing in the Plane - Dual Graphs - Euler's Formula - Characterization of Planar Graphs: Preparation for Kuratowski's Theorem - EDGES: Line Graphs and Edge coloring: Edge Coloring - Characterization of Line Graphs - Hamiltonian cycles: Necessary Conditions - Sufficient Conditions - - Planarity graphs - Coloring and Cycles: Tait's Theorem - Grinberg's Theorem. **(9)**
MATROIDS AND EIGENVALUES OF GRAPHS
Matroids: Properties- The Span function-The Dual of a Matroid - Matroid Minors and Planar Graphs - Matroid Intersection - Matroid Union - Ramsey Theorem - EigenValues of Graphs: Characteristic Polynomial - Linear Algebra of Real Symmetric Matrices- EigenValues and Graph Parameters – Eigenvalues of Regular Graphs - Eigenvalues and Expanders - Strongly Regular Graphs. **(9)**
TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Douglas B West, “Introduction to Graph Theory”, Pearson Education, Second Edition, reprint 2017.

Reference Books

1. Narsingh Deo, “Graph Theory with Applications to Engineering and Computer Science”, Dover Publications, First Edition, 2016.
2. Reinhard Diestel, “Graph Theory”, Springer Publications, 4th Edition, 2010.
3. Bondy J A and Murthy U S R, “Graph Theory with Applications”, Elsevier science ltd / North – Holland 1976.

	Professional Elective
Subject Code	**21ADE08**
Subject Title	**Virtual Reality**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of the course is to provide Virtual reality principles and its associated components viz., computing architecture, Modelling and programming toolkits of VR systems. To gain insight into the basics and functional components of AR systems, its interaction and applications.

Course Outcome

CO1: To understand how the design of VR technology relates to human perception
CO2: To learn the architecture and working of the technology enabling virtual reality
CO3: To get to know the applications of VR to the conduct of scientific research, education and robotics
CO4: To explore the fundamentals of Augmented reality and learn the hardware and software components of Augmented Reality
CO5: To get to know the techniques to create audio and visual AR content

INTRODUCTION TO VIRTUAL REALITY

The three I's of Virtual Reality (VR) – History of Virtual Reality - Early Commercial VR Technology - Basic components of a VR system – VR input devices – 3D position trackers – Navigation and Manipulation interfaces – Gesture interfaces – Output devices – Graphics – Sound – Haptic feedback. **(9)**

VR ARCHITECTURE, MODELING AND PROGRAMMING

VR Computing Architecture: Rendering pipeline – PC graphics architecture – Workstation based architecture – Distributed architecture – Modeling: Geometric modeling – Kinematics modeling – Behaviour modeling – VR Programming – Toolkits and scene graphs – Worldtoolkit – Java 3D – General haptics open software toolkits – Peopleshop. **(9)**

VR APPLICATIONS

Medical applications of VR – Military applications – VR in Robotics – Information visualization. **(9)**

AUGMENTED REALITY

Introduction to Augmented Reality – Working of AR – Ingredients of AR –Hardware components of AR systems – Software components of AR systems. **(9)**

AR APPLICATIONS

Creating visual, audio and sensible contents – Interaction in AR – Application areas of Augmented Reality – Applying and evaluating augmented reality – Introduction to Mobile AR – Architecture of Mobile AR systems – Advantages/Disadvantages of Mobile AR. **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Grigore C Burdea, Philippe coiffet, "Virtual Reality: Technology", Wiley India, 2nd edition, 2003.
2. Alan B Craig, "Understanding Augmented Reality: Concepts and Applications", Morgan Kaufmann publications, 1st edition, 2013.

Reference Books

1. Sherman, William R and Alan B Craig, "Understanding Virtual Reality – Interface, Application, and Design", Morgan Kaufmann, 2002.
2. Fei GAO, "Design and Development of Virtual Reality Application System", Tsinghua Press, March 2012.
3. Greg Kipper, Joseph Rampolla, "Augmented Reality: An Emerging Technologies Guide to AR", Syngress, 2013.
4. Jon Peddie, "Augmented Reality - where we will all live", springer, 2017.

	Professional Electives
Subject Code	**21ADE09**
Subject Title	**Regression Analysis**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course focuses on building a greater understanding, theoretical underpinning, and tools for applying the linear regression mode. With a practical focus, it explores the workings of multiple regression and problems that arise in applying it.

Course Outcome

CO1: To learn the fundamental theory behind linear regression with data samples

CO2: To understand how to fit and apply a regression model to identify relationships between multiple variables.

CO3: To achieve the ability to identify the critical features of data which influences the regression model results

CO4: To build and fit Linear Regression models; interpret estimates and diagnostic statistics.

CO5: To learn about the theory underlying Logistic Regression and Poisson Regression models

INTRODUCTION TO SIMPLE LINEAR REGRESSION

Introduction: Regression and Model Building - Data Collection - Uses of Regression - Role of the Computer - Simple Linear Regression: Simple Linear Regression Model - Least Squares Estimation of the Parameters - Hypothesis Testing on the Slope and Intercept- Interval Estimation in Simple Linear Regression - Prediction of New Observations - Coefficient of Determination - Considerations in the Use of Regression - Regression

through the Origin - Estimation by Maximum Likelihood - Case Where the Regressor x is Random **(9)**
MULTIPLE LINEAR REGRESSION
Multiple linear regression models - Estimation of the Model Parameters - Hypothesis Testing in Multiple Linear Regression - Confidence Intervals in Multiple Regression - Prediction of New Observations - Hidden Extrapolation in Multiple Regression - Standardized Regression Coefficient - Multicollinearity - Reasons for Regression Coefficient having the Wrong Sign **(9)**
MODEL ADEQUACY CHECKING
Introduction - Residual Analysis: Definition of Residuals - Methods for Scaling Residuals Residual Plots - Partial Regression and Partial Residual Plots - Residual Plotting and Analysis Methods - PRESS Statistic -Detection and Treatment of Outliers - Lack of Fit of the Regression Model: A Formal Test for Lack of Fit - Estimation of Pure Error from Near-Neighbors **(9)**
MODEL BUILDING
Introduction: The Model Building Problem - Consequences of Model Misspecification - Criteria for Evaluating Subset Regression Models - Computational Techniques for Variable Selection: All Possible Regression - Stepwise Regression Methods - Multicollinearity: Sources and Effects of Multicollinearity - Multicollinearity Diagnostics - Methods for Dealing with Multicollinearity: Collecting Additional Data - Model Respecification - Ridge Regression **(9)**
GENERALIZED LINEAR MODELS
Introduction - Logistic Regression Models: Models with a Binary Response Variable - Estimating the Parameters in a Logistic Regression Model - Interpretation of the Parameters in a Logistic Regression Model - Hypothesis Tests on Model Parameters - Poisson Regression - The Generalized Linear Model: Link Functions and Linear predictors - Parameter Estimation and Inference in the GLM - Prediction and Estimation with GLM - Residual Analysis in the GLM - Overdispersion (**9)**
TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Douglas C Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, “Introduction to Linear Regression Analysis”, Wiley Publication, 2006

Reference Books

1. Samprit Chatterjee, Ali S Hadi, “Regression Analysis by Example”, 5th Edition, Willey, 2013
2. Norman R Draper, Harry Smith, “Applied Regression Analysis”, Wiley, 1998
3. Andre I Khuri, “Linear Model Methodology”, CRC Press, 2010

	Professional Electives
Subject Code	**21ADE10**
Subject Title	**Software Testing**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to study fundamental concepts in software testing, including software testing objectives, process, criteria, strategies, and methods. To discuss various software testing issues and solutions in software unit test; integration, regression, and system testing. To learn how to plan a test project, design test cases and data, conduct testing operations, manage software problems and defects, generate a testing report.

Course Outcome

CO1: To understand the process of software development, fundamentals and realities of software testing

CO2: To classify the various types of testing for software applications

CO3: To comprehend the automation of software testing

CO4: To realize the importance of documentation for software testing.

CO5: To identify the role of people of an organization in various stages of software testing

PRINCIPLES OF TESTING

Software Testing Background - Software Development Process - Realities of Software Testing - Testing Fundamentals - Examining the Specification - Testing the Software with Blinders on - Testing the Code - Testing the Software with X- Ray Glasses **(9)**

TYPES OF TESTING

White box testing: static testing, structural testing and challenges -Blackbox testing: Boundary value analysis, Equivalence partitioning, Decision tables, domain testing -Integration testing -System and acceptance testing -Regression testing -Performance -Ad hoc testing -Usability and accessibility testing **(9)**

TEST MANAGEMENT AND AUTOMATION

Test Planning -Test management -Test Process- Test reporting -Best practices -Test automation -Test metrics and measurements **(9)**

TEST DOCUMENTATION AND QUALITY ASSURANCE

Test Documentation - Test Effort - Tracking Test Cases - Reporting Measuring Success - Software Quality Assurance **(9)**

PEOPLE AND ORGANIZATION ISSUES IN TESTING

Common people issues- Testing team structure in single production companies -Structure of Multi-product companies Effects on globalization and geographically distributed teams on product testing -Testing service organizations **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Srinivasan Desikan, "Software Testing: Principles and Practice", Pearson, 2006

Reference Books

1. Ron Patton, "Software Testing", 2nd Edition, SAMS, 2000
2. Paul C Jorgensen, "Software Testing: A Craftsman's Approach", Fourth Edition, CRC Press, 1995
3. Boris Beizer, "Software Testing Techniques, 2nd edition", 1990
4. Lisa Crispin and Janet Gregory, "Agile Testing: A Practical Guide for Testers and Agile Teams", Addison Wesely, 2009

	Professional Electives
Subject Code	**21ADE11**
Subject Title	**Reinforcement Learning**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD42 – Machine Learning Techniques 21AD61 - Deep Learning Techniques
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course's objective is to provide a solid introduction to the field of reinforcement learning and students will learn about the core challenges and approaches, including generalization and exploration.

Course Outcome

CO1: To understand how intelligent agents ought to take actions in an environment in order to maximize the notion of cumulative reward.
CO2: To gain knowledge in statistical learning techniques where an agent explicitly takes actions and interacts with the world
CO3: To formalize problems as Markov Decision Processes
CO4: To comprehend the principles of Temporal Difference Learning
CO5: To perceive the applications of Reinforcement Learning

THE REINFORCEMENT LEARNING PROBLEMS

Reinforcement Learning - Elements of Reinforcement Learning - Limitations and Scope - An Extended Example: Tic-Tac-Toe. **(9)**

TABULAR SOLUTION METHODS – I

Multi-arm Bandits: An n-Armed Bandit Problem - Action-Value Methods - Incremental Implementation - Tracking a Nonstationary Problem - Optimistic Initial Values - Upper-Confidence-Bound Action Selection - Gradient Bandits - Associative Search (Contextual Bandits) **(9)**

TABULAR SOLUTION METHODS - II

Finite Markov Decision Processes : The Agent–Environment Interface - Goals and Rewards, Returns - Unified Notation for Episodic and Continuing Tasks - The Markov Property - Markov Decision Processes - Value Functions - Optimal Value Functions - Optimality and Approximation **(9)**	
TEMPORAL_DIFFERENCE LEARNING	
TD Prediction - Advantages of TD Prediction Methods - Optimality of TD(0) - Sarsa: On-Policy TD Control - Q-Learning: Off-Policy TD Control - Games, Afterstates, and Other Special Cases **(9)**	
CASE STUDIES	
The Acrobot - Elevator Dispatching - Job-Shop Scheduling **(9)**	
TOTAL : 45	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Richard S Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", The MIT Press, 2015.

Reference Books

1. Sugiyama Masashi, "Statistical reinforcement learning: modern machine learning approaches," First Edition, CRC Press, 2015.
2. Lattimore T and C Szepesvári, "Bandit algorithms," First Edition, Cambridge University Press.

<table>
<tr><td></td><td>Professional Electives</td></tr>
<tr><td>Subject Code</td><td>21ADE12</td></tr>
<tr><td>Subject Title</td><td>Fundamentals of Blockchain</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>NIL</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The subject aims to provide conceptual understanding of how block chain technology can be used to innovate and improve business processes. The course also covers the technological underpinning of block chain operations in both theoretical and practical implementation of solutions using block chain technology.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To see the advantages of decentralized money and understand the technologies behind Blockchain
CO2: To revisit the cryptographic primitives used in the Blockchain Technology and to gain an in-depth comprehension of the working of Bitcoins and Blockchains.
CO3: To perceive the limitations of Bitcoins and reasoning behind the development of alternate coins.
CO4: To know about Ethereum and its working.
CO5: To gain a hands-on experience of developing Ethereum.</td></tr>
<tr><td colspan="2">FOUNDATIONS OF BLOCKCHAIN TECHNOLOGY</td></tr>
</table>

Distributed Systems - History of Blockchain - Introduction to Blockchain: Technical Definitions - Blockchain Elements - Blockchain Features - Accumulation of Blocks by Blockchain - Types of Blockchain - Consensus in Blockchain - CAP Theorem and Blockchain - Benefits and Limitations of Blockchain - Decentralization: Decentralization using Blockchain - Methods of Decentralization - Routes to Decentralization - Full ecosystem Decentralization - Smart Contract - Decentralized Organizations, Corporations and Society - Decentralized Applications - Platforms for Decentralization **(9)**

BITCOIN AND BLOCKCHAIN

Cryptographic Primitives - Symmetric Cryptography - AES - DES - Asymmetric Cryptography - Hash Functions - Public key cryptography- Digital Signature Algorithm - Hashing - Bitcoin - Transactions - Blockchain: Structure of a Block and Block Header - The Genesis Block - The Bitcoin Network - Wallets - Bitcoin Payments **(9)**

ALTERNATIVE COINS

Theoretical Foundations: Alternative to Proof Work - Difficulty Adjustment and Retargeting Algorithms - Bitcoin Limitations: Privacy and Anonymity - Extended protocols on Top of Bitcoins - Development of Altcoins - - Namecoin - Litecoin - Primecoin - Zcash **(9)**

ETHEREUM

Introduction to Ethereum - Ethereum Blockchain - Elements of Ethereum Blockchain - Precompiled Contracts - Accounts - Block - Ether - Messages - Mining - Clients and Wallets - Trading and Investment - The yellow Paper - The Ethereum Network - Applications developed on Ethereum - Scalability and Security Issues **(9)**

ETHEREUM DEVELOPMENT

Setting up the Development Environment: Test Net - Setting up a Private Net - Starting up the Private Network - - Development Tools and Clients - Introducing Solidity - Introduction to Web 3: Post Requests - HTML and Javascript Frontend - Development Frameworks **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Daniel Drescher, “Block Chain Basics”, Apress; 1stedition, 2017

Reference Books

1. Anshul Kaushik, “Block Chain and Crypto Currencies” , Khanna Publishing House, 2018
2. Imran Bashir, “Mastering Block Chain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Packt Publishing, 2018
3. Melanie Swan, “Block Chain: Blueprint for a New Economy”, O’Reilly, 2015
4. Josh Thompsons, “Block Chain: The Block Chain for Beginners- Guide to Block chain Technology and Leveraging Block Chain Programming”, 2017

	Professional Electives
Subject Code	**21ADE13**
Subject Title	**Evolutionary Algorithms**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course focuses on the fundamentals of biological evolution as the underlying motivation, the main variants of evolutionary algorithms (genetic algorithms and evolution strategies), application examples, and some outlook into related aspects of evolutionary computation.

Course Outcome

CO1: To learn to formulate a given problem as an optimization problem and apply evolutionary approaches

CO2: To understand the foundation of Genetic Algorithm and its solution for various problems.

CO3: To learn in-detail the workings of PSO, Memetic Algorithms.

CO4: To become aware of Differential Evolution and Artificial Bee Colony Algorithms in the context of solving optimization problems.

CO5: To explain evolutionary computation techniques and methodologies set in the context of modern heuristic methods.

INTRODUCTION TO MULTI OBJECTIVE OPTIMIZATION

Single and Multi Objective Optimization - Fundamental Differences - Approaches to Multi Objective Optimization - Evolutionary Algorithms For Multi Objective Optimizations - Rise of Multi - Objective Optimization Evolutionary Algorithms - Linear and Nonlinear MOOP - Convex and Non Convex MOOP - Principles of Multi Objective Optimization - Dominance and Pareto Optimality **(9)**

GENETIC ALGORITHMS

Historical development, GA concepts – encoding, fitness function, population size, selection, crossover and mutation operators, along with the methodologies of applying these operators. Binary GA and their operators, Real Coded GA and their operators **(9)**

PARTICLE SWARM OPTIMIZATION AND ARTIFICIAL BEE COLONY

PSO Model, global best, Local best, velocity update equations, position update equations, velocity clamping, inertia weight, constriction coefficients, synchronous and asynchronous updates, Binary PSO - Artificial Bee Colony: Historical development, types of bees and their role in the optimization process. **(9)**

MEMETIC ALGORITHMS

Concepts of memes, Incorporating local search as memes, single and multi-memes, hybridization with GA and PSO, Generation Gaps, Performance metrics. **(9)**

DIFFERENTIAL EVOLUTION

DE as modified GA -Generation of population, operators and their implementation **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Deb K, "Multi-Objective Optimization using Evolutionary Algorithms", John wiley and Sons, 2002.
2. Coello C A, Van Veldhuizen, D A and Lamont G B, "Evolutionary Algorithms for solving Multi Objective Problems", Kluwer, 2002.

Reference Books

1. Deb K , "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, 1998.
2. Gen M and Cheng R, "Genetic Algorithms and Engineering Design", Wiley, New York, 1997.

<table>
<tr><td></td><td>Professional Electives</td></tr>
<tr><td>Subject Code</td><td>21ADE14</td></tr>
<tr><td>Subject Title</td><td>Digital Forensics</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 Hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>N/A</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The course’s objective is to understand the fundamentals of computer forensics , the associated legal aspects of forensics and to imbibe the best practices for general incidence response</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To comprehend the fundamentals of Digital Forensic Systems
CO2: To get familiarized with the types of evidence and the end-to-end process of collecting and preserving evidence
CO3: To understand how evidences are analyzed and the past scenarios are reconstructed
CO4: To gain an understanding of intrusion detection in Networks and traffic analysis.
CO5: To explore the basics of Indian laws governing Cyber Security</td></tr>
<tr><td colspan="2">INTRODUCTION TO COMPUTER FORENSICS</td></tr>
<tr><td colspan="2">Computer Forensics Fundamentals - Types of Computer Forensics Technology - Types of Computer Forensics Systems - Types of Vendor and Computer Forensics Services.
(9)</td></tr>
<tr><td colspan="2">COMPUTER FORENSICS EVIDENCE</td></tr>
<tr><td colspan="2">Data recovery: Definition and solution, Evidence collection and data seizure: Collection options - Obstacles - Types of evidence - Rules of evidence - Volatile evidence, Duplication and preservation of digital evidence, Computer image verification and authentication (9)</td></tr>
<tr><td colspan="2">COMPUTER FORENSICS ANALYSIS</td></tr>
</table>

Discovery of electronic evidence, E-Discovery, Identification of data, Reconstructing past events, Network forensics scenario, System testing, Damaging computer evidence. **(9)**

INTRUSION DETECTION

Network vs. Host based detection, Anatomy and process, Network based and host based intrusion detection systems: Architecture - Detection engine - Operational concept - Benefits and challenges, Detection mechanism, Signatures, Traffic analysis, Intrusion detection **(9)**

SURVEILLANCE AND IT-ACT

The Information Warfare Arsenal of the Future - Surveillance Tools for Information Warfare of the Future - IT Act: Concepts – Sections, Digital laws and legislation, Basics of Indian evidence act: IPC – CrPC. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. John R Vacca, "Computer forensics: Computer Crime Scene Investigation", Second Edition, Charles River Media, Firewall, 2009.
2. Paul E Proctor, "The Practical Intrusion Detection Handbook", Prentice Hall, USA, 2007.

Reference Books

1. Vivek Sood, "Cyber Law Simplified", Tata McGraw Hill, New Delhi, 2008.
2. Warren G Kruse II and Jay G Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, USA, 2010.
3. Eogen Casey, "Digital Evidence and Computer Crime", Elsevier, USA, 2011.
4. Chad Steel, "Windows Forensics: The Field Guide for Conducting Corporate Computer Investigations" Wiley India, 2006.

	Professional Elective
Subject Code	**21ADE15**
Subject Title	**Distributed Systems**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course is about establishing the basic principles of distributed systems. It explains the scope of their functionality by discussing what they can and cannot achieve. It also covers the basic algorithms and protocols of distributed systems through easy-to-follow examples and diagrams that illustrate the thinking behind some design decisions and expand on how they can be practiced.

Course Outcome

CO1: To conceive the challenges and issues in applying various distributed system models in real time applications.

CO2: To comprehend interprocess communication using Remote Method Invocation and Remote Procedure Call

CO3: To analyze the architecture and security provided by the OS layer to support the Distributed System.

CO4: To identify the design issues related to naming services, synchronization and use synchronization algorithms in various distributed system scenarios.

CO5: To classify various consistency models and understand the approaches to achieve fault tolerance in a distributed environment.

BASICS OF DISTRIBUTED SYSTEM

Characterization of Distributed Systems - Examples - Resource Sharing - Challenges - web. System Models - Architectural and Fundamental Models. **(9)**

PROCESSES AND DISTRIBUTED OBJECTS

InterProcess Communication - The API for the Internet Protocols - External Data Representation and Marshaling - Client- Server Communication - Group Communication - Distributed Objects and Remote Invocation - Communication Between Distributed Objects - Remote Procedure Call. **(9)**

OPERATING SYSTEM SUPPORT AND NAMING SERVICES

The OS Layer - Protection - Processes and Threads - Communication and Invocation - OS Architecture Distributed File Systems: File Service Architecture-Name Services: Name Services and the domain Name System-Directory Services. **(9)**

SYNCHRONIZATION AND MUTUAL EXCLUSION

Time and Global States: Clocks, Events and Process States - Synchronizing Physical Clocks - Logical Time And Logical Clocks - Global States. Coordination and Agreement: Distributed Mutual Exclusion - Elections - Multicast Communication **(9)**

CONSISTENCY AND REPLICATION

Data-centric consistency models: Continuous consistency- Consistent ordering of operations. Client-centric consistency models: Eventual consistency - Monotonic Reads - Monotonic Writes - Read your writes - Writes Follow Reads. Replica Management: Replica-Server Placement - Content Replication and Placement -Content Distribution. Consistency protocols: Continuous Consistency - Primary-Based Protocols - Replicated-Write Protocols - Cache - Coherence Protocols. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. George Coulouris, Jean Dollimore and Tim Kindberg, "Distributed Systems Concepts and Design", Pearson Education, 5th Edition, 2017.
2. Andrew S Tanenbaum, Maartenvan Steen, "Distributed Systems -Principles and Paradigms", Pearson Education, Second Edition, 2015. (consistency & replication only)

Reference Books

1. Ajay D Kshem Kalyani and Mukesh Singhal, "Distributed computing principles, Algorithms and Systems", Cambridge University Press, First edition, 2011.
2. Mukesh Singhal and Niranjan G. Shivaratri, "Advanced concepts in Operating Systems", First Edition, Tata McGraw Hill, 2017.
3. M L Liu, "Distributed computing Principles and Applications", 1st Edition, Pearson Education, 2019.

	Professional Electives
Subject Code	**21ADE16**
Subject Title	**Cyber-Physical Systems**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course introduces cyber physical system to the which focused on different ubiquitous applications we interact in our day to day life ranging from simple system to mission critical applications.

Course Outcome

CO1: To understand the basic concepts and applications domains of CPS

CO2: To learn the components of CPS platform

CO3: To understand the synchronous and asynchronous model in CPS

CO4: To learn the fundamentals of securities in CPS

CO5: To foster understanding through real-world applications related to CPS

BASICS OF CPS

Cyber-Physical System- Key Features of CPS -Application Domains of CPS -Basic principles of design and validation of CPS -Challenges in CPS. **(9)**

CPS PLATFORM COMPONENT

HW platforms -Processors, Sensors and Actuators -CPS Network - Wireless, CAN, Automotive Ethernet -Scheduling Real Time CPS tasks -Synchronous Model and Asynchronous Model. **(9)**

SYNCHRONOUS AND ASYNCHRONOUS MODEL

Reactive Components -Components Properties -Components Composing- Synchronous Designs and Circuits- Asynchronous Processes and operations - Design Primitives in Asynchronous Process- Coordination Protocols in Asynchronous Process- Reliable Transmission **(9)**
SECURITY OF CYBER PHYSICAL SYSTEMS
Introduction to CPS Securities -Basic Techniques in CPS Securities - Cyber Security Requirements- Attack Model and Countermeasures -Advanced Techniques in CPS Securities. **(9)**
CPS APPLICATION
Health care and Medical Cyber-Physical Systems -Smart grid and Energy- CyberPhysical Systems- WSN based Cyber-Physical Systems -Smart Cities **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.

Reference Book

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
2. Raj Rajkumar, Dionisio de Niz and Mark Klein, "Cyber-Physical Systems", Addison-Wesley, 2017
3. Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2015
4. Fei Hu, "Cyber-Physical Systems", CRC Press 2013

	Professional Electives
Subject Code	**21ADE17**
Subject Title	**Social Media Analytics**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of this course is to enable the students to grasp the analytics tools to leverage social media data. The course will introduce tools such as data identification, data analysis and deep data analysis to mine relevant information from social media.

Course Outcome

CO1: To know the methods to collect data from the right places**.**
CO2: To explore methods to collect data from social media.
CO3: To revisit the methods of data mining for data collected from social media.
CO4: To get to know ad hoc and deep analysis of data.
CO5: To explore the tools for analysis and decide the right one for interpreting the data.

DATA IDENTIFICATION

Looking for Data in the Right Places: Relevant Data - Subset of Content of Interest - Attributes of Data: Structure - Language - Region - Type of Content - Venue - Time - Ownership of Data - Starting with Data - Casting a Net - Regular Expressions - Looking for Right Set of People - Identifying Emotional State: Location and Language - Age and gender - Eminence, Prestige or Popularity

(9)

SOCIAL DATA

Predictive vs Descriptive Analysis - Sentiment - Time as the Friend - Structured Data vs Unstructured Data - Big Data - Sifting Through Big Data - Identifying Data in Social Media Outlets **(9)**

DATA ANALYSIS

Four Dimensions of Analysis Taxonomy - Depth of Analysis - Machine Capacity - Domain of Analysis - Velocity of Data - Validating Hypothesis: Youth Unemployment - Cannes Lions 2013 - 56th Grammy Awards - Discovering Themes and Topics - Using Iterative Methods - Value in Real Time - Real Time vs Near real Time - Stream Computing - IBM InfoSphere - SPL Applications - Directed Graphs - Streams example: SSM - Value Derived from a Conference using Real-time Analytics **(9)**

DEEP ANALYSIS

Adhoc Analysis - Example of Adhoc Analysis - Data Integrity - Deep Analysis: Responding to Leads Identified in Social Media - Support for Deep Analysis in Analytics Software - Enterprise Social Network: Transparency of Communication - Frictionless Redistribution of knowledge - Deconstructing Knowledge Creation - Serendipitous Discovery and Innovation - Enterprise Social Network is the Memory of the Organization - Understanding the Enterprise Graph - Personal Social Dashboard **(9)**

INFORMATION INTERPRETATION

The Social Analytics Process - Finding the Right Data - Clear Communication -Choosing Filter Words - Understanding Less is More - Customizing and Modifying Tools - Using Right Tool for the Right Job - Analyzing Consumer Reaction during Hurricane Sandy - Visualization as an Aid to Analytics: Common Visualizations - Common Pitfalls - Visually Representing Unstructured Data **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Matthew Ganis and Avinash Kohirkar, “Social Media Analytics: Techniques and insights for Extracting Business Value out of Social Media”, Pearson, 2016.

Reference Books

1. Szabo G, G Polatkan, O Boykin and A Chalkiopoulus (2019), “Social Media Data Mining and Analytics”, Wiley, ISBN 978-1-118-82485-6
2. Jim Sterne, “Social Media Metrics: How to Measure and Optimize Your Marketing Investment”, 2018.
3. Oliver Blanchard, “Social Media ROI: Managing and Measuring Social Media Efforts in Your Organization (Que Biz-Tech)”, Que Publishing, 2018.

<table>
<tr><td></td><td colspan="4">Professional Electives</td></tr>
<tr><td>Subject Code</td><td colspan="4">21ADE18</td></tr>
<tr><td>Subject Title</td><td colspan="4">DevOps</td></tr>
<tr><td>Duration</td><td colspan="4">One Semester</td></tr>
<tr><td>Total Contact Hours</td><td colspan="4">45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td colspan="4">NIL</td></tr>
<tr><td>Credit Points</td><td colspan="4">3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td></td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Assessment Type</td><td colspan="4">Theory</td></tr>
<tr><td>Course Objective</td><td colspan="4">This subject will introduce the principles and DevOps concepts for Continuous Integration, Continuous Delivery/Deployment along with containerization principles and container orchestration strategies. The course will also introduce continuous monitoring DevOps on Cloud. Various enterprise level tools will be introduced such as Jenkins, Dockers, Kubernetes etc.</td></tr>
<tr><td colspan="5">Course Outcome
CO1: To understand and learn why automation, culture, and metrics are essential to a successful DevOps project and understand the role of Linux in DevOps.
CO2: To comprehend the fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability and benefits
CO3: To be able to gain deep insights and knowledge into different tools which includes Jenkins, Gits and Docker
CO4: To understand about Containers and Dockers and its working
CO5: To learn about Kubernetes and what it is used for and managing application deployments with rollouts in Kubernetes</td></tr>
<tr><td colspan="5">Fundamentals of DevOps</td></tr>
<tr><td colspan="5">DevOps Basics - DevOps History - Software Development Lifecycle and DevOps-Agile Model and practices-Continuous integration and deployment process-Containers-Configuration management tools-Linux basics -Linux in DevOps-Linux basic commands
(9)</td></tr>
<tr><td colspan="5">Cloud Computing</td></tr>
</table>

Overview of Cloud-Infrastructure as service-Platform as a service-Software as a service-Private cloud-Public cloud-Hybrid cloud-AWS-Azure-Google cloud **(9)**

Continuous Integration Tools: Git JenKin and Maven

Jenkin: Basics of Jenkins-Continuous Integration with Jenkins-Configure Jenkins-Management of JenKin-Scheduling build Job-Build and Test Git: Git Features-Git Hub Projects-Git Management-Installing gits and common commands-Git Rebase and Merge-Git clone, push and pull Maven Maven Installation-Maven Build requirements-Maven Build cycles-Maven dependencies-Maven plugins **(9)**

Containers

What is Container-Docker Image-Docker Installation-Working with Docker Containers-Docker Engine-Docker Swarm- Network types-Container networking-Docker files and commands **(9)**

Kubernetes

Cluster architecture-Kubernetes dashboard installation-Rolling updates and management-Various business Case for DevOps **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Mark Reed, "DevOps: The Ultimate Beginners Guide to Learn DevOps Step-By-Step", Publishing factory LLC, 2020

Reference Books

1. Mikael Krief, "Learning DevOps: The complete guide to accelerate collaboration with Jenkins, Kubernetes, Terraform and Azure DevOps", Packt Publishing, 2019
2. Gene Kim, "The DevOPS Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations", IT Revolution Press, 2016
3. Rajkumar Buyya, "Cloud Computing: Principles and Paradigms", Wiley, 2013
4. Saibal Ghosh, "Docker Demystified: Learn How To Develop And Deploy Applications Using Docker", 2020
5. Joseph Muli, "Jenkins Fundamentals: Accelerate deliverables, manage builds, and automate pipelines with Jenkins" , Packt Publishing, 2018

	Professional Electives
Subject Code	**21ADE19**
Subject Title	**Mining Large Datasets**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD32 – Data Structures and Algorithms 21AD43 - Database Management Systems
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The aim of this course is to explore data mining and machine learning algorithms for analyzing very large amounts of data, particularly emphasizing on Map Reduce (as a tool) for creating parallel algorithms that can process very large amounts of data.

Course Outcomes

CO1: To understand the concepts of MapReduce and methods to find similar items.

CO2: To learn techniques for mining data streams and performing link analysis

CO3: To comprehend the need for clustering and to learn various clustering techniques.

CO4: To explore how the social media data can be viewed mined for multiple applications

CO5: To gain understanding of parallel algorithms and dimensionality reduction

MAP REDUCE AND MINING DATA STREAMS

Map Reduce: Distributed File Systems – MapReduce - Algorithms Using MapReduce - Finding Similar Items: Applications of Near-Neighbour Search - Shingling of Documents - Similarity-Preserving Summaries of Sets - Locality-Sensitive Hashing for Documents - Distance Measures - The Theory of Locality-Sensitive Functions **(9)**

MINING DATA STREAMS AND LINK ANALYSIS

Mining Data Streams: The Stream Data Model - Sampling Data in a Stream - Filtering Streams - Counting Distinct Elements in a Stream - Estimating Moments - Counting Ones in a Window - Decaying Windows - Link Analysis: PageRank - Efficient Computation of PageRank - Topic-Sensitive PageRank - Link Spam - Hubs and Authorities **(9)**

FREQUENT ITEMSETS AND CLUSTERING

Frequent Itemsets: The Market-Basket Model - Market Baskets and the A-Priori Algorithm - Handling Larger Datasets in Main Memory - Limited-Pass Algorithms - Counting Frequent Items in a Stream - Clustering: Introduction to Clustering Techniques - Hierarchical Clustering - K-means Algorithms - The CURE Algorithm - Clustering in Non-Euclidean Spaces - Clustering for Streams and Parallelism **(9)**

RECOMMENDATION SYSTEMS AND SOCIAL-NETWORK GRAPHS

A Model for Recommendation Systems - Content-Based Recommendations - Collaborative Filtering - Dimensionality Reduction - Netflix Challenge - Social Networks as Graphs - Clustering of Social-Network Graphs - Direct Discovery of Communities - Partitioning of Graphs - Finding Overlapping Communities - Counting Triangles - Neighbourhood Properties of Graphs **(9)**

DIMENSIONALITY REDUCTION

Eigenvalues and Eigenvectors of Symmetric Matrices - Principal-Component Analysis - Singular-Value Decomposition - CUR Decomposition, Introduction to Parallel Algorithms - Large-Scale Machine Learning: The Machine-Learning Model - Perceptrons - Support-Vector Machines - Learning from Nearest Neighbours -Comparison of Learning Methods **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Jure Leskovec, Anand Rajaraman and Jeffrey D. Ullman, "Mining of Massive Datasets", 3rd Edition, Cambridge University Press, 2020.

Reference Books

1. Jared Dean, "Big Data, Data Mining, and Machine Learning", 1st Edition, Wiley, 2014.
2. Michael J Quinn, "Parallel Computing: Theory and Practice", Tata Mcgraw-Hill, 2004.

	Professional Elective
Subject Code	**21ADE20**
Subject Title	**Information Theory and Coding**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective is to gain knowledge in the philosophies of information theory, source coding, channel and channel capacity, channel coding and relationship among them and also to acquire potential experience in finding optimal solutions for real-life applications using coding theory.

Course Outcomes

CO1: To gain insight into the fundamentals of probability, essential parameters of information theory and employ it in source coding and channel coding techniques to compute various operational parameters.
CO2: To identify and devise error detecting and error correcting capabilities of the code and sketch the encoder configurations.
CO3: To determine the final code word by choosing the suitable text compression technique for the given scenario and discuss various kinds of speech compression techniques.
CO4: To analyze image and audio compression techniques and infer about the encoding and decoding of digital data streams.
CO5: To understand the principles of video compression techniques and the various standards associated with them.

FUNDAMENTALS OF INFORMATION THEORY

Uncertainty - Information and Entropy - Information rate - conditional and Joint entropies - Mutual information. Source Coding: Prefix codes - Kraft McMillan Inequality. Entropy Coding: Source Coding Theorem - Shannon - Fano Coding - Static Huffman Coding. Channel Coding: Discrete Memoryless Channel - Channel models - Cascaded channels - Channel capacity - Channel coding theorem - Information capacity theorem. **(9)**

ERROR CONTROL CODING

Linear Block codes: Introduction to Error Correcting Coding- Basic Definitions- Matrix description of linear block codes – Decoding of Linear Block codes - Syndrome decoding. Cyclic codes: Generator polynomial - Parity check polynomial - Encoder of cyclic codes - Calculation of syndrome. Convolution codes: Introduction - Code Tree, Trellis, State diagram - Encoding - Decoding: Feedback decoding, Sequential decoding and Viterbi algorithm. **(9)**

TEXT AND SPEECH COMPRESSION

Text Compression: Huffman Coding - Arithmetic coding - Adaptive Dictionary: LZ77-LZ78 – LZW- Subband Coding : The Basic Subband Coding Algorithm - Speech Compression : Channel Vocoder - Linear Predictive Coder - Code excited Linear Prediction- Mixed Excitation Linear Prediction –Wideband Speech Compression : ITU-T G.722.2 **(9)**

IMAGE AND AUDIO COMPRESSION

Lossless Image Compression: CALIC- JPEG-LS. Wavelet –based Image Compression: Embedded Zero Tree Coder – Set Partitioning in Hierarchical Trees- JPEG 2000 - Audio coding : MPEG Audio Coding — Dolby AC-3 **(9)**

VIDEO COMPRESSION

Motion Compensation - Video Signal Representation - ITU-T Recommendation H.261 – MPEG-1 Video Standard – MPEG-2 Video Standard- ITU-T Recommendation H.264, MPEG - 4. **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Ranjan Bose, "Information Theory, Coding and Cryptography", Tata McGraw Hill, Second Edition, Eighth Reprint, 2010.
2. Khalid Sayood, "Introduction to Data Compression", Elsevier, Fourth Edition, 2012.

Reference Books

1. Fred Halsall, "Multimedia Communications: Applications, Networks, Protocols and Standards", Pearson Education Limited, Fourth impression, 2009.
2. Todd K Moon, "Error Correction Coding: Mathematical Methods and algorithms", John Wiley & Sons, First Edition, 2005.

	Professional Electives
Subject Code	**21ADE21**
Subject Title	**AI in Healthcare**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to provide conceptual understanding of AI and its application through medical case studies. The subjects also introduces to the students how machine learning models are effectively used in health care.

Course Outcome

CO1: To understand the role of AI in Healthcare

CO2: To comprehend the role of AI in Telehealth and Drug Discovery

CO3: To identify and understand the use of AI in various fields of Medicine.

CO4: To perceive the role of major corporations in AI in Healthcare

CO5: To analyze the future of AI in Healthcare

INTRODUCTION TO AI IN HEALTHCARE

AI vs Human Intelligence – Introduction to AI in healthcare- AI-augmented health care- FDA Approved AI applications in Medicine - Healthcare Data - AI Blackbox issue and Explainable AI- Future of AI in Healthcare - NLP in Healthcare **(9)**

TELEHEALTH AND DRUG DISCOVERY

AI in Telehealth - AI in the fight against COVID - AI in Drug Discovery and Development - AI in Healthcare Robotics - AI in Health Records, Insurance and Education: Electronic health records Health and Medical data ownership - AI in Health Insurance - AI in Medical Education **(9)**

AI IN HEALTHCARE SPECIALITIES

Preventive Healthcare - Nutrition - Radiology - Pathology - Surgery Anesthesiology - Pain Medicine - Psychiatry - Cardiology - Pharmacy - Dentistry - Orthopedics - Critical Care Medicine - Emergency Medicine - Endocrinology - Oncology - Infectious Diseases **(9)**

TECHNOLOGY ENABLERS IN AI HEALTHCARE

IBM Watson- Google and Deepmind in AI – Baidu in Healthcare - Facebook in Healthcare- Amazon in Healthcare- Microsoft in Healthcare - Apple in Healthcare - NVIDIA in Healthcare- GE in healthcare – Siemens in Healthcare - Philips in Healthcare **(9)**

AI IN GENOMIC AND PRECISION MEDICINE

AI in Genomic medicine - AI in Precision medicine - Virtual Health , Medical Assistants and Virtual Hospitals - Advanced Technologies and the Implications for Medical Applications **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Books

1. Dr Parag Suresh Mahajan M, "Artificial Intelligence in Healthcare: AI, Machine Learning, and Deep and Intelligent Medicine Simplified for Everyone", 2019

Reference Books

1. Panesar and Arjun, "Machine Learning and AI for Healthcare Big Data for Improved Health Outcomes", 2019
2. Sandeep Reddy, "Artificial Intelligence Applications in Healthcare Delivery" Productivity Press, 2020
3. Larry Keeley and Helen Walters, Ryan Pikkel, Brian Quinn, "Ten Types of Innovation: The Discipline of Building Breakthroughs", Wiley, 2013.
4. Hoyt R and Hersh W, "Health Informatics: Practical Guide", 7th edition, Lulu, 2018

	Professional Electives
Subject Code	**21ADE22**
Subject Title	**Financial AI**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to introduce the concepts of AI in fintech industry. The subject introduces to the students, the areas of finance like Cryptocurrencies, Insurance where AI is being used extensively.

Course Outcome

CO1: To understand the AI concepts and latest AI technologies in finance industry

CO2: To perceive the key driving changes in business models, products and applications in finance industry

CO3: To learn in detail the concepts of deep learning, blockchain and open APIs

CO4: To gain insight as to how AI can change the Insurance industry for the better.

CO5: To be able to understand the legal and ethical issues in financial service sector

AI IN FINTECH

Introduction to financial industry- Key technological trends in fin tech- The Changing Accounting Landscape - The Future of AI in Finance - Navigating a Sea of Information, News and Opinion with Augmented Human Intelligence - A New Internet, Data Banks and Digital World War - AI: A Cross Country Analysis of China versus the West - The AI Advantage: Near-Term Workforce Opportunities and Challenges - The Art of Involving Boards in Embracing AI **(9)**

CRYPTOCURRENCIES AND BLOCKCHAIN

AI in financial industry – Blockchain technology- Cryptocurrency - Cryptocurrencies & The Financial Services Landscape - Consensus Methodologies - Stablecoins & The Decentralized Organization **(9)**

DEPOSITS AND LENDINGS

AI in Lending - Financial Technology and China's Inclusive Finance - The Future of Deposits and Lending - Applications of AI in Deposits and Lending - Showcase and Customer Service: Leveraging Chatbots in the Banking Industry - The Power of AI to Transform the Global SME Credit Landscape **(9)**

INSURANCE AND AI

Insurance and AI - Algocratic Insurance - Strategies for Health Insurers to Put AI into Practice - Using Artificial Intelligence in Commercial Underwriting - The Digitally - Enabled Underwriter - Improving Policy Life Cycle Management with AI and Data Science - Disrupting the Insurance Value Chain - Mapping AI to the Real-World Insurance Value Chain **(9)**

PAYMENTS

AI - The Next Leap Forward in the Payments Revolution - Frictionless Payments - Unlock The Potential of Big Data, AI and Machine Learning in the New Payment Environment - The Rise of Conversational AI Platforms - Two Dimensional Virtual Vertical Integration **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Susanne Chishti, Ivana Bartoletti, Anne Leslie and Shân M Millie, "The AI Book: The Artificial Intelligence Handbook for Investors, Entrepreneurs and FinTech Visionaries", 2020.

Reference Books

1. German Creamer, Gary Kazantsev and Tomaso Aste, "Machine Learning and AI in Finance", CRC Press, 2021.
2. Stein Smith Sean, "Blockchain, Artificial Intelligence and Financial Services, Springer, 2020.
3. Henri Arslanian, "The Future of Finance: The Impact of FinTech, AI, and Crypto on Financial Services" Palgrave Macmillan, 2019.
4. Yves Hilpisch, "Artificial Intelligence in Finance: A Python-Based Guide", OReilly, 2020.

	Professional Electives
Subject Code	**21ADE23**
Subject Title	**Intelligent systems**
Duration	**One Semester**
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course is intended to bring to the students the information necessary to understand the design, operation and capabilities of intelligent systems. Students will be introduced to the fundamental concepts of machine learning with neural and fuzzy components. Latest topics are included to keep in touch with the recent trends.

Course Outcome

CO1: To be able to explain the concepts of intelligent systems

CO2: To have a statistical view of the uncertainty and understand the fundamentals of the workings of fuzzy systems.

CO3: To understand the characteristics of Intelligent Agents

CO4: To know the working of Hybrid and Interpretation Systems

CO5: To gain an understanding of the applications of intelligent systems

INTRODUCTION

Intelligent Systems-A Spectrum of Intelligent Behaviour-Knowledge-Based Systems-The Knowledge Base - Deduction, Abduction, and Induction-The Inference Engine-Declarative and Procedural Programming- Expert Systems-Knowledge Acquisition-Search-Computational Intelligence-Integration with Other Software Rule Based Systems - Rules and Facts - A Rule-Based System for Boiler Control-Rule Examination and Rule Firing-Maintaining Consistency-The Closed-World Assumption-Use of Local Variables within Rules-Forward Chaining - Conflict Resolution - Backward Chaining - Hybrid Strategy

(9)

HANDLING UNCERTAINTY

Sources of Uncertainty-Bayesian Updating- Introduction to Certainty Theory - Making Uncertain Hypotheses - Logical Combinations of Evidence - Worked Example of Certainty Theory - Discussion of the worked example - Relating Certain Factors to Probabilities - Possibility Theory: fuzzy sets and fuzzy logic - Dempster - Inferno **(9)**
INTELLIGENT AGENTS
Characteristics of an Intelligent Agent - Agents and Objects - Agent Architectures - Multiagent Systems - Symbolic Learning: Introduction - Learning by Induction - Case-Based- Reasoning -Optimization Algorithms: Search Space - Searching the search space - Hill Climbing and Gradient Descent Algorithms - Simulated Annealing - Genetic Algorithms **(9)**
HYBRID SYSTEMS AND INTERPRETATION SYSTEMS
Convergence of Techniques - Blackboard Systems - Genetic Fuzzy Systems - Neuro Fuzzy Systems - Genetic Neural Systems - Clarifying and Verifying Neural Networks - Learning Classifier Systems - Systems for Interpretation and Diagnosis: Deduction and Abduction for Diagnosis - Depth of Knowledge - Model Based Reasoning **(9)**
SYSTEMS FOR DESIGN AND SELECTION
Evolutionary Computation- Data Mining- Autonomous mental development- Synthetic Biometrics for Testing Biometric Systems and User Training **(9)**
TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Adrian A Hopgood, “Intelligent Systems for Engineers and Scientists”, 3rd Edition, CRC Press, 2011
2. I Bogdan M Wilamowski and J. David Irwin, “Intelligent Systems”, CRC Press, 2011

Reference Books

1. Dr Michael Negnevitsky, “Artificial Intelligence: A Guide to Intelligent Systems”, Adisson Wesley, 2004
2. Nikolopoulos, “Expert Systems: Introduction to First and Second Generation and Hybrid Knowledge Based Systems”, CRC Press, 2004
3. Peter Jackson, “Introduction to Expert System,”, Pearson, 2002
4. Stuart Russell and Peter Norvig,” Artificial Intelligence: A Modern Approach” Prentice-Hall, 2003

	Professional Electives
Subject Code	**21ADE24**
Subject Title	**Fog Computing**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course will provide a solid base for understanding the challenges and problems underlying the design and development of fog and edge computing systems and applications. This course will teach how to specify, design, program, analyze and implement such systems and applications.

Course Outcome

CO1: To learn the basics of IoT, edge and fog computing

CO2: To comprehend the optimization challenges in fog computing

CO3: To understand the data management techniques in fog computing

CO4: To explore the state of art techniques in fog computing applications

CO5: To become aware of the legal aspects of IoT in Fog Computing

INTERNET OF THINGS AND NEW COMPUTING PARADIGMS

Introduction to IoT-Relevant Technologies-Fog and edge computing completing the cloud-Hierarchy of fog and edge computing-Business Models-Opportunity and challenges-Addressing the challenges in federating edge resources: Introduction - The Networking Challenge - The Management Challenge - Miscellaneous Challenges **(9)**

OPTIMIZATION PROBLEMS IN FOG AND EDGE COMPUTING

Optimization Problems in Fog and Edge Computing-Formal modelling framework-Optimization opportunities along the fog architecture-Optimization opportunities along the Service Life Cycle-Middleware for Fog and Edge-Lightweight container middleware for edge architecture **(9)**

DATA MANAGEMENT IN FOG COMPUTING	
Fog data management- Predictive analysis to support Fog application deployment: Introduction Example: Smart Building - Predictive Analysis with FogTorch -Machine learning in protecting the security and privacy of IoT systems: Introduction - Survey of ML Techniques for Defending IoT Devices - Machine Learning in Fog Computing **(9)**	
APPLICATION AND ISSUES - I	
Fog computing realization for big data analytics: Introduction - Big Data Analytics - Data Analytics in the Fog - Prototypes and Evaluation - Architecture - Configurations -Fog computing in health monitoring: Introduction - An Architecture of a Health Monitoring IoT-Based System with Fog Computing - Fog Computing Services in Smart E-Health Gateways - System Implementation - Case Studies **(9)**	
APPLICATION AND ISSUES - II	
Smart surveillance video stream processing at the edge for real -time human object tracking-Fog computing model for smart transportation-Fog Based IoT applications- Legal aspects of operating IoT application in the fog **(9)**	
	TOTAL : 45
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Satish Narayana Srirama, Rajkumar Buyya, "Fog and Edge Computing: Principles and Paradigms" , Wiley, 2018

Reference Book

1. Ajit Singh, "Edge Computing", Shrif Publishers, 2019
2. Perry Lea, "IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security", Packt Publishing, 2020
3. C S R Prabhu, "Fog Computing and Internet-of-Things", BS Publications, 2019

<table>
<tr><td></td><td>Professional Electives</td></tr>
<tr><td>Subject Code</td><td>21ADE25</td></tr>
<tr><td>Subject Title</td><td>Business Analytics</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>NIL</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The course’s objective is to make the students gain an understanding of how business analytics is used to formulate and solve business problems and to support managerial decision making. To become familiar with the processes needed to develop, report, and analyze business data.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To gain an in-depth understanding of the fundamentals of business analytics
CO2: To be able to recognize the role of business intelligence in organizations
CO3: To explore various Forecasting techniques and gain the ability to choose the appropriate forecasting method.
CO4: To gain an in-sight into the decision analysis process.
CO5: To identify the Six Sigma Process and understand how it effectively increases efficiency of Business processes.</td></tr>
<tr><td colspan="2">Introduction to Business Analytics</td></tr>
<tr><td colspan="2">Why Business Analytics-Business Analytics: The Science of Data-Driven Decision Making-Descriptive Analytics-Predictive Analytics-Prescriptive Analytics-Descriptive, Predictive and Prescriptive Analytics Techniques-Big Data Analytics-Web and Social Media Analytics-Machine Learning Algorithms-Framework for Data-Driven Decision Making - Analytics Capability Building-Roadmap for Analytics Capability Building-Challenges in Data-Driven Decision Making and future (9)</td></tr>
<tr><td colspan="2">Business Intelligence</td></tr>
</table>

Business Intelligence (BI) and Its Impacts-Business Intelligence Capabilities-BI the Big Data Era-Technologies Enabling Business Intelligence-Development of Business Intelligence-Business Intelligence Tools and Vendors-Management of Business Intelligence-The Future of Business Intelligence **(9)**

Forecasting Techniques

Objectives -Qualitative and Judgemental Forecasting - Statistical Forecasting Models for Stationary Time Series - Forecasting Models for Time Series with a Linear Trend - Forecasting Time Series with Seasonality - Selecting the Apt Time series based Forecasting Model **(9)**

Decision Analysis

Learning Objectives - Formulating Decision Problems - Decision Strategies without Outcome Probabilities - Decision Strategies with Outcome Probabilities - Decision Trees - Value of Information **(9)**

Six Sigma

Introduction to Six Sigma-What is Six Sigma?-Origins of Six Sigma-Three-Sigma versus Six-Sigma Process-Cost of Poor Quality-Sigma Score-Industrial Applications of Six Sigma-Six Sigma Measures-Defects Per Million Opportunities (DPMO)-Yield-Sigma Score (or Sigma Quality Level)-DMAIC Methodology-Six Sigma Project Selection For DMAIC Implementation-DMAIC Methodology **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. U Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Pearson, 2017
2. Sabherwal, R & Becerra-Fernandez, “Business intelligence: practices, technologies, and management”, Wiley, 2011

Reference Books

1. R Evans James, “Business Analytics”, Pearson, 2017
2. Sharda R, Delen, D Turban, E, Aronson J and Liang T P, “Business Intelligence and Analytics: Systems for Decision Support” , Pearson, 2014.
3. Jeffrey D Camm, James J Cochran, Michael J Fry, Jeffrey W Ohlmann, David R Anderson, Dennis J Sweeney, Thomas A Williams, “Essentials of Business Analytics” , Cengage learning, 2014
4. Albright Winston, “Business Analytics data analysis and decision-making”, Cengage Learning, 2014

Semester	**Professional Elective**
Subject Code	**21ADE26**
Subject Title	**Speech Recognition**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	--
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory

Course Outcome

CO1: Understanding the basic concepts of Signal, Signal processing and Speech Recognition

CO2: Ability to understand system design and implementation

CO3: To understand the implementation of hidden markov models

CO4: The ability to apply speech recognition based on connected world models

CO5: Acquire knowledge in large vocabulary continuous speech recognition

INTRODUCTION TO SPEECH RECOGNITION AND SIGNAL

Introduction- Paradigm of Speech Recognition, The Speech Signal: Production, Perception and Acoustics- Phonetic Characterization- Approaches to automatic speech recognition by machine. **(9)**

SIGNAL PROCESSING AND ANALYSIS METHODS FOR SPEECH RECOGNITION

Bank of Filter front end processor- Linear predictive coding model – vector quantization- Patter Comparison Techniques: Spectral distortion techniques- Time alignment and normalization. **(9)**

SYSTEM DESIGN AND IMPLEMENTATION

Application of Source Coding Technique-Template Training Methods-Performance analysis and recognition enhancements-Template adaptation to new talkers-Discriminative methods **(9)**

IMPLEMENTATION OF HIDDEN MARKOV MODELS

Discrete time Markov process- Extensions to HMM-Three basic problems of HMM-Types of HMM- Continous observation Densities in HMMs-Autoregressive HMMs- Variants of HMM structure- Comparisons of HMM-Implementation issues- Model Clustering and splitting. **(9)**

SPEECH RECOGNITION BASED ON CONNECTED WORLD MODELS

Introduction- Two level dynamic programming- Level building algorithm-One pass algorithm- Multiple candidate string- Large vocabulary continuous speech recognition: Subword speech units- Context dependant subword speech. **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Books

1. L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, “Fundamentals of speech recognition”, Pearson Education, 2009.
2. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis Discrete-Time Processing of Speech Signals, Wiley-IEEE Press, NY, USA, 1999.
3. D. O’Shaughnessy, Speech Communications: Human and Machine, Second Edition,University Press, 2005.
4. J. Benesty, M. M. Sondhi and Y. Huang, “Handbook of speech processing”, Springer, 2008.

	Professional Electives
Subject Code	**21ADE27**
Subject Title	**Neural Networks in Cognitive Science**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD33 - Principles of Artificial Intelligence
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of the course is to investigate a few neural mechanisms that may be underlying our human behaviour. Additionally, seeking to simulate some of these capabilities on computational systems to understand the internal mechanics of these systems.

Course Outcome

CO1: To gain the ability to build the primitive blocks of cognitive models
CO2: To understand Rosenblatt's Perceptron
CO3: To be able to simulate and test a given cognitive model
CO4: To gain an in-depth understanding of Least Mean Square Analysis
CO5: To gain fundamental knowledge and to be able to work with Multilayer Perceptron

BASICS OF NEURAL NETWORKS

Neural Networks – Models – Neural Networks as Graphs – Feedback – Network Architecture – Knowledge representation – Learning Processes – Learning Tasks. **(9)**

ROSENBLATT'S PERCEPTRON

Perceptron – Perceptron Convergence Theorem - Relation between the perceptron and Bayes classifier for a Gaussian environment – Computer Experiment: Pattern Classification – The Batch perceptron algorithm **(9)**

MODEL BUILDING THROUGH REGRESSION

Linear Regression Model – Maximum a Posteriori estimation of the parameter vector – Regularized Least-Square Estimation and MAP estimation relationship – Computer Experiment: Pattern Classification. - Minimum - Description Length Principle - Finite Sample Size Consideration - The Instrumental Variables Method **(9)**

LEAST MEAN SQUARE(LMS) ANALYSIS	
Filtering of the LMS algorithm – Review of Unconstrained Optimization - The Weiner Filter – The LMS algorithm – Markov Model Portraying from the Weiner Filter - The Langevian Equation - Kushner's Direct Averaging Method - Statistical LMS Theory - Linear Prediction - Pattern Classification - Virtues and Limitations of LMS ALgorithm - Learning Rate Annealing Schedules. **(9)**	
MULTILAYER PERCEPTRON	
Batch learning and On-Line Learning – The Back Propagation algorithm – XOR problem – Heuristics for Back propagation algorithm improvisation. **(9)**	
	TOTAL : 45
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Books

1. Simon Haykin, "Neural Networks and Learning Machines", 3rd Edition, Pearson – Prentice Hall, 2009.

Reference Books

2. James McClelland and David E Rumelhart, "Explorations in parallel distributed processing", The MIT Press, 1991.
3. Bishop and Christopher M, " Pattern Recognition and Machine Learning", Springer, 2006

	Professional Elective
Subject Code	**21ADE28**
Subject Title	**Game Theory in AI**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD33 – Principles of Artificial Intelligence
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The purpose of this course is to introduce the basics of game theory to students. The course also aims to sharpen student's understanding of strategic behavior in different situations involving many individuals.

Course Outcome

CO1: To know how Game theory works and explore its multiple engineering and social applications.

CO2: To attain the ability to create a simple model of a given game situation and predict its probable future evolution.

CO3: To design an AI model for a simple soccer game

CO4: To explore the use of Graph Theory in Gaming AI

CO5: To gain an in-depth understanding of the Path Planning mechanisms

STATE-DRIVEN AGENT DESIGN

Finite State Machines(FSM) – Implementing a Finite State Machine: State Transition Tables - Embedded Rules - The West World Project - The BaseGameEntity Class - The Miner Class - The Miner States - The State Design Pattern Revisited - Making the State Base Class Reusable - Global States and State Blips - Creating a State Machine Class: Elsa introduction - Adding Messaging Capabilities to Your FSM **(9)**

AUTONOMOUSLY MOVING GAME AGENTS

Autonomous Agent - The Vehicle Model: Updating the Vehicle Physics - The Steering Behaviors: Seek - Flee - Arrive - Pursuit - Evade - Wander - Obstacle Avoidance - Wall Avoidance - Interpose - Hide - Path Following - Offset Pursuit - Group Behaviors: Separation - Alignment - Cohesion - Flocking - Combining Steering Behaviors: Weighted Truncated

Sum - Weighted Truncated Running Sum with Prioritization - Ensuring Zero Overlap - Coping with Lots of Vehicles: Spatial Partitioning - Smoothing **(9)**

SPORTS SIMULATION

The Simple Soccer Environment and Rules: The Soccer Pitch - The Goals - The Soccer Ball - Designing the AI: The SoccerTeam Class - Field Players - Goalkeepers - Key Methods Used by the AI - Making Estimates and Assumptions **(9)**

GRAPHS IN GAME AI

Graphs: Formal Descriptions -Trees - Graph Density - Digraphs - Graphs in Game AI - Implementing a Graph Class: The GraphNode Class - The GraphEdge Class - The SparseGraph Class - Graph Search Algorithms: Uninformed Graph Searches - Cost-Based Graph Searches: Edge Relaxation - Shortest Path Trees - Dijkstra's Algorithm - Dijkstra with a Twist **(9)**

PRACTICAL PATH PLANNING

Navigation Graph Construction: Tile Based - Points of Visibility - Expanded Geometry - NavMesh - The Raven Navigation Graph: Coarsely Granulated Graphs - Finely Grained Graphs - Adding Items to the Raven Navigation Graph - Using Spatial Partitioning to Speed Up Proximity Queries A Path Planner Class creation: Planning a Path to a Position - Planning a Path to an Item Type - Paths as Nodes vs Paths as Edges: An Annotated Edge Class Example - Modifying the Path Planner Class to Accommodate Annotated Edges - Path Smoothing - Getting Out of Sticky Situations **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Mat Buckland," Programming Game AI by Example", Wordware Publishing, Inc, 2005.

Reference Books

1. Brian Schwab, "AI Game Engine Programming", Cengage Learning, 2nd edition, 2009.

	Professional Electives
Subject Code	**21ADE29**
Subject Title	**GPU Computing**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	21AD33 - Principles of Artificial Intelligence
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective is to understand the basics of GPU architectures and to learn parallel programming with graphics processing units (GPUs). To learn the CUDA architecture, programming with CUDA and develop efficient methods to solve a given problem with GPUs.

Course Outcome

CO1: To understand GPU Architectures

CO2: To explore the CUDA Architecture and to know the fundamentals to begin programming with CUDA

CO3: To gain an in depth understanding of how memory is handled with CUDA

CO4: To know to implement efficient algorithms for common application kernels, such as AES

CO5: To be able to develop an efficient parallel algorithm to solve a given problem.

BASICS OF UPERCOMPUTING

History of Supercomputing - Parallelism with GPU - Traditional Serial Code - Serial/Parallel Problems - Concurrency - Types of Parallelism - Flynn's Taxonomy - Parallel Patterns - CUDA Hardware: PC Architecture - GPU Hardware - CPUs and GPUs - Compute Levels **(9)**

CUDA PROGRAMMING - I

Setting up CUDA - Grids, Blocks and Threads: Threads:Problem Decomposition - CPU GPU Difference - Task Execution Model - Threading on GPUs - A peek at Hardware - CUDA Kernels - Blocks - Grids - Warps - Block Scheduling - Example of Histogram **(9)**

CUDA PROGRAMMING - II	
Memory Handling with CUDA: Introduction - Caches - Register Usage - Shared Memory: Sorting Using Shared Memories - Radix Sort - Merging Lists - Parallel Merging - Parallel Reduction - A Hybrid Approach - Shared Memory on Different GPUs - Constant Memory - Global Memory - Texture Memory **(9)**	
CUDA IN PRACTICE	
Introduction - Serial and Parallel Code - Processing Datasets - Profiling - Example Using AES: The Algorithm - Serial Implementations of AES - An Initial Kernel - Kernel Performance - Transfer Performance - Single Streaming Version - Comparison with CPU - Running on other GPUs - Using Multiple Streams - AES Summary **(9)**	
OPTIMIZING APPLICATIONS	
Parallel/Serial GPU/ CPU Problem Breakdown - Memory Considerations - Transfers - Thread Usage, Calculations and Divergence: Thread Memory Patterns - Inactive Threads - Arithmetic Density - Compiler Optimizations - Divergence - Understanding Low-Level Assembly Code - Register Usage **(9)**	
TOTAL : 45	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing)", 1st Edition, Morgan Kaufmann, 2012.

Reference Book

1. Nicholas Wilt, "CUDA Handbook: A Comprehensive Guide to GPU Programming", Addison Wesley, 2013.
2. Jason Sanders and Edward Kandrot, "CUDA by Example: An Introduction to General Purpose GPU Programming", Addison Wesley, 2010.
3. David R Kaeli, Perhaad Mistry, Dana Schaa and Dong Ping Zhang, "Heterogeneous Computing with OpenCL", 3rd Edition, Morgan Kauffman, 2015.

	Professional Electives
Subject Code	**21ADE30**
Subject Title	**Ethical Hacking**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to introduces the knowledge, tools, techniques and customised training of ethical hacking, leading to the capability to perform Capture the Flag (CTF) challenges and penetration tests

Course Outcome

CO1: To explore the concepts of security testing and the knowledge required to protect against the hacker and attackers.

CO2: To understand reconnaissance and the publicly available tools used to gather information on potential targets.

CO3: To discover the scanning techniques used to identify network systems open ports and identify network system vulnerabilities and confirm their exploitability.

CO4: To learn techniques for identifying web application vulnerabilities and attacks.

CO5: To understand the working of various penetration testing tools.

BASICS OF HACKING

Introduction to Hacking – Important Terminologies – Penetration Test – Vulnerability Assessments versus Penetration Test – Pre-Engagement – Rules of Engagement – Penetration Testing Methodologies – OSSTMM – NIST – OWASP – Categories of Penetration Test – Types of Penetration Tests – Vulnerability Assessment Summary – Reports. **(9)**

INFORMATION GATHERING AND SCANNING

Information Gathering Techniques – Active Information Gathering – Passive Information Gathering – Sources of Information Gathering – Tracing the Location – Traceroute – ICMP Traceroute – TCP Traceroute – Usage – UDP Traceroute – Enumerating and Fingerprinting the Webservers – Google Hacking – DNS Enumeration – Enumerating SNMP – SMTP Enumeration – Target Enumeration and Port Scanning Techniques – Advanced Firewall/IDS Evading Techniques. **(9)**

VULNERABILITY ASSESSMENT AND NETWORK SNIFFING

Vulnerability Data Resources – Exploit Databases – Network Sniffing – Types of Sniffing – Promiscuous versus Nonpromiscuous Mode – MITM Attacks – ARP Attacks – Denial of Service Attacks –Hijacking Session with MITM Attack – SSL Strip: Stripping HTTPS Traffic – DNS Spoofing – ARP Spoofing Attack Manipulating the DNS Records – DHCP Spoofing – Remote Exploitation – Attacking Network Remote Services – Overview of Brute Force Attacks – Traditional Brute Force – Attacking SMTP – Attacking SQL Servers – Testing for Weak Authentication. **(9)**

EXPLOITATION

Introduction to Metasploit – Reconnaissance with Metasploit – Port Scanning with Metasploit – Compromising a Windows Host with Metasploit – Client Side Exploitation Methods – E– Mails with Malicious Attachments – Creating a Custom Executable – Creating a Backdoor with SET – PDF Hacking – Social Engineering Toolkit – Browser Exploitation – Post– Exploitation – Acquiring Situation Awareness – Hashing Algorithms – Windows Hashing Methods – Cracking the Hashes – Brute force Dictionary Attacks – Password Salts – Rainbow Tables – John the Ripper – Gathering OS Information – Harvesting Stored Credentials. **(9)**

PENETRATION TESTING

Wireless Hacking – Introducing Aircrack– Cracking the WEP – Cracking a WPA/WPA2 Wireless Network Using Aircrack-ng – Evil Twin Attack – Causing Denial of Service on the Original AP – Web Hacking – Attacking the Authentication – Brute Force and Dictionary Attacks – Types of Authentication – Log-In Protection Mechanisms – Captcha Validation Flaw – Captcha RESET Flaw – Manipulating User-Agents to Bypass Captcha and Other Protection – Authentication Bypass Attacks – Testing for the Vulnerability – Automating It with Burp Suite – Session Attacks – SQL Injection Attacks – XSS (Cross-Site Scripting) – Types of Cross-Site Scripting – Cross-Site Request Forgery (CSRF) – SSRF Attacks. **(9)**

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Rafay Baloch, “Ethical Hacking and Penetration Testing Guide”, CRC Press, 2014

Reference Books

1. Hein Smith, “Ethical hacking: A Comprehensive Beginner’s Guide to Learn and Master Ethical Hacking”, 2018
2. Simson Garfinkel, “Web Security, Privacy and Commerce”, ORielly, 2011
3. Jon Erickson, “Hacking: The Art of Exploitation”, No Starch Press, 2011
4. Allen Haper, “Gray Hat Hacking the Ethical Hacker's Handbook”, Tata McGraw Hill, 2014
5. Paco Hope, “Web Security Testing Cookbook”, OReilly, 2008.

Subject Code	**21ADE31**
Subject Title	**Principles of Robotics**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	Principle of Robotics course provides an introduction to the various concepts of robotic systems, highlighting on exploring designing and devising robots based on different tasks with impacts and applications of Robots, either as an independent system or as a part of a large system.

Course Outcome

CO1: To understand the basic terminologies and concepts of robotics

CO2: To understand the grippers and types of grippers in robotics

CO3 : To familiarize with drivers and controls of robotics

CO4: To learn the basic programming languages applied in robotic systems

CO5 : To understand the societal impacts and latest trends in robotics

INTRODUCTION TO ROBOTICS

Brief History- Basic Concepts of Robotics : Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc. - Classification of Robotic systems on the basis of various parameters such as work volume, type of drives - Associated parameters i.e. Resolution, accuracy, repeatability, dexterity, compliance, RCC device etc - Introduction to Principles & Strategies of Automation, Types & Levels of Automations- Need of automation, Industrial applications of robot.

(9)

GRIPPERS AND SENSORS FOR ROBOTICS

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system -Sensors for Robots - Types of Sensors used in Robotics- Classification and applications of sensors- Characteristics of sensing devices-

Selections of sensors. Need for sensors and vision system in the working and control of a robot. **(9)**

DRIVES AND CONTROL FOR ROBOTICS

Drive - Types of Drives- Types of transmission systems, Actuators and its selection while designing a robot system -Control Systems: Types of Controllers, Introduction to closed loop control **(9)**

BASIC PROGRAMMING AND LANGUAGES FOR ROBOTICS

Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines -Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS

(9)

SOCIETY IMPACTS AND TRENDS IN ROBOTICS

Socio-Economic aspect of robotization- Economical aspects for robot design- Safety for robot and standards - Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics **(9)**

TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd, 2020

REFERENCE BOOKS

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education , 2014
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, 2006
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2019
4. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi ,2003

Subject Code	**21ADE32**
Subject Title	**Mechanics of Robotics**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course aims to inculcate thorough understanding about basic knowledge of mathematics, kinematics and dynamics required for understanding motion programming and operational / control functionality in robotics.

Course Outcome

CO1: To understand the mathematical preliminaries of robotics

CO2: To understand terminologies related to Kinematics and Dynamics of Robotics

CO3 : To apply mathematics for manipulator positioning and motion planning

CO4: To analyse basics of motion programming as per kinematics

CO5 : To estimate the force/torque required to drive a robot

MATHEMATICAL PRELIMINARIES OF ROBOTICS

Spatial Descriptions: positions orientations, and frame, mappings: changing description from frame to frame - Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. **(9)**

ROBOT KINEMATICS

Manipulator Kinematics -Link Description - Link to reference frame connections- Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics -Inverse Kinematics, Geometric and analytical approach. **(9)**

VELOCITIES & STATICS

Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, Jacobian Jv / Jw, Jacobian in a Frame - Jacobian in Frame {0}- Kinematic Singularity, Kinematics redundancy- Force balance equation -Forces, Velocity/Force Duality- Virtual Work- Force ellipsoid Jacobian- Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages **(9)**

ROBOT DYNAMICS I

Introduction to Dynamics- Velocity Kinematics- Acceleration of rigid body, mass distribution Newton's equation **(9)**

ROBOT DYNAMICS II

Euler's equation -Iterative Newton –Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational considerations **(9)**

TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison- Wesley, 2003

REFERENCE BOOKS

1. S. K. Saha, "Introduction to Robotics 2e, TATA McGraw Hills Education", 2014.
2. Dilip Kumar Pratihar, "Fundamentals of Robotics", Narosa Publishing House, 2019.
3. Asitava Ghoshal, "Robotics: Fundamental concepts and analysis", Oxford University Press, 2006
4. Spong, M. Vidyasagar, S. Hutchinson, "Robot Modeling and Control", Wiley & Sons, 2005.

Subject Code	**21ADE33**
Subject Title	**Control of Robotic Systems**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course aims to develop the understanding of control systems, its designing and application

Course Outcome

CO1: To understand the basic control mechanism of robotics

CO2: To learn the concepts of linear control systems in robotics

CO3 : To learn the concepts of non-linear control systems in robotics

CO4: To understand the motion control systems

CO5 : To learn the forced control system of manipulators in robotics

Basics of Control

Differential Equation - Transfer function- Frequency response- Routh-Hurwitz test- relative stability- Root locus design, construction of root loci, phase lead and phase-lag design- lag-lead design, Bode, polar, Nyquist plot **(9)**

Linear Control

Concept of states- state space model- different form- controllability, observability; pole placement by state feedback- observer design- P, PI & PID Controller- control law partitioning- modelling and control of a single joint. **(9)**

Non-Linear Control System

Common physical non-linear system- phase plane method, system analysis by phase plane method, stability of non-linear system - stability analysis by describing function method - Liapunov's stability criterion -the control problems for manipulators. **(9)**

Motion Control
Point to Point Control, trajectory generation- Continuous Path Control- Joint based control- Cartesian Control- Force Control -hybrid position/force control system **(9)**
Forced Control of Manipulators
Application of Industrial Robots to assembly tasks- Framework for control in partially constrained tasks-force control of mass-spring systems- current industrial-robot control systems **(9)**
TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. M. Gopal, "Control Systems", McGraw-Hill, 2012

REFERENCE BOOKS

2. K. Ogata, "Modern Control Engineering", Prentice Hall India, 2009.
3. M. Spong, M. Vidyasagar, S. Hutchinson, "Robot Modeling and Control", Wiley & Sons, 2005.
4. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley, 2003
5. S. K. Saha, "Introduction to Robotics 2e"s, TATA McGraw Hills Education, 2014
6. Thomas Kailath, "Linear Systems", Prentice Hall , 1980

Subject Code	**21ADE34**
Subject Title	**Machine Learning for Robotics**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course introduces the concepts of machine learning and neural networks in robots with case studies.

Course Outcome

CO1: To discuss about the concepts of machine learning

CO2: To outline the supervised learning methods with various case studies

CO3: To compare the learning methodologies and dimensionality concepts

CO4: To summarize the applications of neural networks in robotic applications.

CO5: To illustrate the applications of machine learning using case studies

INTRODUCTION

Machine learning – Varieties of Machine learning – Learning Input- Output functions: Types of learning – Input Vectors – Outputs – Training regimes – Noise – Performance Evaluation. **(9)**

SUPERVISED LEARNING MODELS

Decision trees and inductive bias – Geometry and nearest neighbors – Logistic regression – Perceptron – Binary classification- Linear models and gradient descent – Support Vector machines – Naïve Bayes models and probabilistic -modeling – Model selection and feature selection – Model Complexity and Regularization **(9)**

UNSUPERVISED LEARNING

Curse of dimensionality, Dimensionality Reduction, PCA, Clustering – K-means – Expectation Maximization

Algorithm – Mixtures of latent variable models – Supervised learning after clustering – Hierarchical clustering **(9)**

NEURAL NETWORKS

Network Representation, Feed-forward Networks, Back propagation, Gradient-descent method.

(9)

CASE STUDIES

Line following using Supervised Learning techniques – A simulation model for understanding both regression and classification techniques - Study of the effectiveness of the Bias-variance. Obstacle avoidance and navigation of a mobile robot in an unknown environment with the help of Neural Network -Use of stochastic PCA and the PCA neural network to find low dimensional features. Building a feed-forward neural network to ascertain automatic navigational queries. **(9)**

TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. Michalski, Carbonell, Tom Mitchell, 'Machine Learning', Springer, 2014.
2. Peter Flach, 'Machine Learning: The Art and Science of Algorithms that make sense of data', Cambridge, 2014.

REFERENCE BOOKS

1. Ethem Alpaydin, "Introduction to Machine Learning", The MIT Press, 2004
2. David MacKay, "Information Theory, Inference and Learning Algorithms", Cambridge, 2003
3. Bruno Apolloni, Ashish Ghosh, Ferda Alpasian, "Machine Learning and Robot Perception", Springer, 2005.
4. Judy Franklin, Tom Mitchell, SebastinThrun, "Recent Advances in Robot Learning: Machine Learning", Springer, 2012.

Subject Code	**21ADE35**
Subject Title	Robot Operating System
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course introduces the basics of Robot Operating Systems and its architecture. It covers the applications of ROS in real world complex applications

Course Outcome

CO1: To describe the need for ROS and its significance

CO2: To summarize the Linux commands used in robotics

CO3: To ain a comprehensive understanding of operating system architectures

CO4: To discuss about the concepts behind navigation through file system.

CO5: To discuss about the applications of ROS

INTRODUCTION TO ROS

Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases. **(9)**

INTRODUCTION TO LINUX COMMANDS

UNIX commands - file system – redirection of input and output - File system security - Changing access rights – process commands – compiling, building and running commands – handling variables **(9)**

ARCHITECTURE OF OPERATING SYSTEM

File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands **(9)**

COMPUTATION GRAPH LEVEL

Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master – parameter server. **(9)**

CASE STUDIES: USING ROS IN REAL WORLD APPLICATIONS

Navigation stack-creating transforms -odometer – imu – laser scan – base controller – robot configuration – cost map – base local planner – global planner – localization – sending goals – TurtleBot – the low cost mobile robot **(9)**

TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018
2. Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing, Ltd, 2013.

REFERENCE BOOKS

1. Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
2. AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
3. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
5. Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

Subject Code	**21ADE36**
Subject Title	**Autonomous Systems**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The course introduces the basics of human autonomous systems. It imparts the knowledge basic structure and layers of autonomous systems. The course allows to develop a deeper understanding architecture and interpretation system.

Course Outcome

CO1: Differentiate systems, agents and issues in modelling autonomous systems

CO2: Validate the concepts of basic structure and types of artificial organ

CO3: Analyse the effect of influence of layers of autonomous systems with agentification.

CO4: Explain the role of interpreting systems and behavioural learning.

CO5: Understand the current representations and tendencies of autonomous systems

INTRODUCTION TO AUTONOUMOUS SYSTEM

Conventional systems- Complex systems- System of systems -Autonomous systems- Agents and multi-agent systems - Systems and organisms - Issues in modelling an autonomous system **(9)**

ARCHITECHURE OF AN AUTONOMOUS SYSTEM

Reactivity of a system - Basic structure of an autonomous system- The membrane of autonomous systems -Two types of proactivity and the notion of artificial organ - Autonomy and current representation in an autonomous system -The unifying system that generates representations. **(9)**

LAYERS OF MULTI-AGENT AUTONOMOUS SYSTEM

Object layer on the substratum- Agent representation of the substratum - Interpretation system and the conception agents -Aggregates, intent and the activity of conception agents- Agentifying conception agents - Activity of a conception agent- Three layers of conceptual

agentification - Semantic lattices and the emergence of representations in the interpretation system **(9)**

ARCHITECHURE OF MULTI AGENT AUTOMONOUS SYSTEM

General architecture of the interpretation system - Agentification of knowledge and organizational memory- Setting up the membrane network of an autonomous system- Behavioral learning of the autonomous system**.** **(9)**

GENERATION OF CURRENT REPRESENTATION AND TENDENCIES

Generation of current representation and semantic lattices; Cause leading the system to choose a concrete intent; Presentation of artificial tendencies; Algorithm for the generation of a stream of representations under tendencies. **(9)**

TOTAL:45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. Alain Cardon, Mhamed Itmi, New Autonomous Systems, Wiley-ISTE- 2016
2. Nikolaus Correll, Introduction to Autonomous Robots, Magellan Scientific, 2016

REFERENCE BOOKS

1. Jitendra R. Raol, Ajith K. Gopal, “Mobile Intelligent Autonomous Systems” CRC Press, 2017.

Subject Code	**21ADE37**
Subject Title	**Basics of Artificial Intelligence**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of the course is to provide a basic understanding of AI, including problem-solving, Machine Learning, Deep Learning, and NLP and to develop practical skills to implement AI algorithms and models using popular frameworks at a rudimentary level.

Course Outcome

CO1: To explain the fundamental concepts and history of Artificial Intelligence and its applications in various industries.

CO2: To apply problem-solving and search algorithms to model and solve real-world AI problems efficiently.

CO3: To implement and evaluate Machine Learning algorithms for tasks like regression, classification, and clustering.

CO4: To build and train Neural Networks for image recognition, natural language processing and other AI applications.

CO5: To analyze and process natural language text using NLP techniques, considering ethical implications in AI language models.

OVERVIEW OF ARTIFICIAL INTELLIGENCE

Definition, history, and applications of AI - AI and its relationship with ML and DL - Types of AI - Narrow AI vs. General AI vs. Superintelligence - Ethical and societal considerations in AI development and deployment - Impact of AI in various industries.

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SEARCH ALGORITHMS

Problem representation in AI - State space, problem space, and goal formulation - Uninformed search algorithms - Breadth-First Search (BFS) and Depth-First Search (DFS) - Informed search algorithms - Best-First Search, A* algorithm, and heuristic functions - Adversarial search and games: Minimax algorithm and Alpha-Beta Pruning - Constraint Satisfaction Problems (CSP) and their solutions.

(9)

KNOWLEDGE REPRESENTATION AND REASONING
Propositional Logic : Syntax, semantics, and truth tables - Logical operators and logical equivalences: First-Order Logic, Predicates, quantifiers, and variables, Inference rules and resolution, Representing knowledge using first-order logic - Knowledge Representation Systems: Semantic Networks, Frames and Scripts. **(10)**
KNOWLEDGE INFERENCE
Knowledge representation -Production based system, Frame based system. Inference – Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory. **(9)**
MACHINE LEARNING ALGORITHMS
Introduction to Machine Learning: Supervised, Unsupervised, and Reinforcement Learning -Regression: Linear regression, polynomial regression, and evaluation metrics - Classification: Logistic regression, k-Nearest Neighbors (k-NN), and decision trees - Clustering: K-Means, Hierarchical Clustering, and evaluation methods. **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Stuart J Russell and Peter Norvig, "Artificial Intelligence- A Modern Approach", Pearson Education Series, Third Edition, 2010.
2. Kevin Night and Elaine Rich, Nair B., “Artificial Intelligence (SIE)”, Mc Graw Hill- 2008. (Units-I,II,VI & V)

Reference Book

1. Deepak Khemani, "A First Course in Artificial Intelligence", McGraw Hill Education, First Edition, 2013.
2. Dan W. Patterson "Introduction to AI and ES", Pearson Education, First Edition, 2007
3. Peter Jackson, “Introduction to Expert Systems”, 3rd Edition, Pearson Education, 2007.
4. Stuart Russel and Peter Norvig “AI – A Modern Approach”, 2nd Edition, Pearson Education 2007.
5. Deepak Khemani “Artificial Intelligence”, Tata Mc Graw Hill Education 2013.

Subject Code	**21ADE38**
Subject Title	**Machine Learning Concepts and Applications**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To provide an understanding of the theoretical concepts of machine learning and prepare students for research or industry application of machine learning techniques.

Course Outcome

CO1: To understand the concepts and mathematical foundations of machine learning and types of problems tackled by machine learning

CO2: To explore the different supervised learning techniques including ensemble methods

CO3: To learn different aspects of unsupervised learning and reinforcement learning

CO4: To learn the role of probabilistic methods for machine learning

CO5: To understand the basic concepts of neural networks and deep learning

INTRODUCTION TO MACHINE LEARNING

Review of Linear Algebra for machine learning; Introduction and motivation for machine learning; Examples of machine learning applications, Vapnik-Chervonenkis (VC) dimension, Probably Approximately Correct (PAC) learning, Hypothesis spaces, Inductive bias, Generalization, Bias variance trade-off

(9)

SUPERVISED LEARNING

Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Perceptron algorithm, Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random Forests

(9)

UNSUPERVISED LEARNING AND REINFORCEMENT LEARNING

Introduction - Clustering Algorithms -K – Means – Hierarchical Clustering - Cluster Validity - Dimensionality Reduction –Principal Component Analysis – Recommendation Systems - EM algorithm. Reinforcement Learning – Elements -Model based Learning – Temporal Difference Learning

(9)

PROBABILISTIC METHODS FOR LEARNING

Introduction -Naïve Bayes Algorithm -Maximum Likelihood -Maximum Apriori -Bayesian Belief Networks -Probabilistic Modelling of Problems -Inference in Bayesian Belief Networks – Probability Density Estimation - Sequence Models – Markov Models – Hidden Markov Models

(9)

NEURAL NETWORKS AND DEEP LEARNING

Neural Networks – Biological Motivation- Perceptron – Multi-layer Perceptron – Feed Forward Network – Back Propagation-Activation and Loss Functions- Limitations of Machine Learning – Deep Learning– Convolution Neural Networks – Recurrent Neural Networks – Use cases

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Reference Book

1. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012
3. EthemAlpaydin, "Introduction to Machine Learning", Third Edition, Adaptive Computation and Machine Learning Series, MIT Press, 2014
4. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2013.
5. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", First Edition, Cambridge University Press, 2012
6. Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2015
7. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
8. Hal Daumé III, "A Course in Machine Learning", 2017 (freely available online)
9. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Springer, 2009 (freely available online)
10. AurélienGéron , Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition, o'reilly, (2017)

Subject Code	**21ADE39**
Subject Title	**Deep Learning**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	Machine Learning Concepts and Applications
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The objective of this course is to empower students with comprehensive knowledge of deep learning fundamentals, enabling them to apply Python and deep learning libraries to build and analyze neural networks.

Course Outcome

CO1: To understand the basic deep learning concepts and Python Programming
CO2: To explore the concepts of supervised learning and Neural Networks
CO3: To examine the performance of various deep learning models like CNN and RNN
CO4: To learn the working of Recurrent Neural Networks
CO5: To explore concepts of Autoencoders, Representation Learning and Unsupervised Training

FOUNDATIONS OF DEEP LEARNING

Introduction to Deep Learning - Differences between AI, Machine Learning and Deep Learning- Basics of Neural Networks - What is a Neuron? - Activation Functions and Layers –Basics of Python Programming – Python libraries – Deep Learning Libraries – Basics of TensorFlow and Keras **(9)**

SUPERVISED LEARNING WITH NEURAL NETWORKS

Basics of Supervised Learning - Introduction to Regression and Classification - Deep Feedforward Networks - Understanding Backpropagation - Creating a simple Neural Network with TensorFlow/Keras - Loss Functions and Optimization - Understanding Loss Functions - Introduction to Gradient Descent - Overfitting and Regularization - Basics of Regularization Techniques **(9)**

CONVOLUTION NEURAL NETWORKS

The Convolution Operation - Pooling - Convolution and Pooling as an Infinitely Strong Prior - Variants of the Basic Convolution Function - Structured Outputs - Data Types - Efficient Convolution Algorithms - Random or Unsupervised Features - The Neuroscientific Basis for Convolutional Networks - Convolutional Networks and the History of Deep Learning

(9)

SEQUENCE MODELING

Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures - Deep Recurrent Networks - Recursive Neural Networks - The Challenge of Long-Term Dependencies - Echo State Networks - Strategies for Multiple Time Scales - The Long Short-Term Memory (LSTM) and Gated RNNs - Optimization for Long-Term Dependencies - Explicit Memory

(9)

AUTOENCODERS AND REPRESENTATION LEARNING

AutoEncoders: Undercomplete Autoencoders - Regularized Autoencoders - Representational Power, Layer Size and Depth - Stochastic Encoders and Decoders - Denoising Autoencoders - Learning Manifolds with Autoencoders - Contractive Autoencoders - Predictive Sparse Decomposition - Applications of Autoencoders - Representation Learning - Transfer Learning and Domain Adaptation - Applications

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", MIT Press, 2016.
2. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127.

Reference Book

1. N.D.Lewis, "Deep Learning Made Easy with R: A Gentle Introduction for Data Science", 2016.
2. Nikhil Buduma, "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms", O'Reilly publications, 2017.
3. Tariq Rashid, "Make your own neural network ", 2017.
4. Yann LeCun, YoshuaBengio& Geoffrey Hinton, “Deep learning”, Nature,Vol: 521, pp: 436 – 444.

Subject Code	**21ADE40**
Subject Title	**Statistics for Business Data Analytics**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course aim to cover the fundamental algorithms and techniques used in business data analytics. The course provides foundation of statistics followed by machine learning and data mining algorithms

Course Outcome

CO1: To understand the foundation of statistics and find a meaningful pattern in data

CO2: To learn how to graphically interpret data

CO3: To understand the data analytics concepts and implement the analytic algorithms

CO4: To handle large scale analytics projects from various domains

CO5: To develop intelligent decision support systems

DATA DEFINITIONS AND ANALYSIS TECHNIQUES

Data Definitions- Elements, Variables, and Data categorization- Levels of Measurement-Data management and indexing -Introduction to statistical learning and R-Programming **(9)**

DESCRIPTIVE STATISTICS

Different Types of Descriptive Statistics: Frequency Distribution, Central Tendency, Variability- Measures of location of dispersions-Descriptive Statistics vs Inferential Statistics **(9)**

BASIC ANALYSIS TECHNIQUES

Basic analysis techniques- Statistical hypothesis generation and testing- Chi-Square test-Test -Analysis of variance-Correlation analysis -Maximum likelihood test **(9)**

DATA ANALYSIS TECHNIQUES

Regression analysis -Classification techniques- Clustering Association rules analysis

(9)

CASE STUDIES

Understanding business scenarios - Feature engineering and visualization - Scalable and parallel computing with Hadoop and Map-Reduce Sensitivity Analysis

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, "Probability & Statistics for Engineers & Scientists", Ninth Edition, Prentice Hall Inc, 2010

REFERENCE BOOKS

1. Trevor Hastie Robert Tibshirani Jerome Friedman, "The Elements of Statistical Learning, Data Mining, Inference, and Prediction"Second Edition, Springer, 2014
2. G James, D. Witten, T Hastie, and R. Tibshirani, "An Introduction to Statistical Learning: with Applications in R", Springer, 2013
3. John M. Chambers , "Software for Data Analysis: Programming with R (Statistics and Computing)", Springer.
4. Anna Maria Paganoni and Piercesare Secchi, "Advances in Complex Data Modeling and Computational Methods in Statistics", Springer, 2013
5. Donald Miner, Adam Shook, "MapReduce Design Patterns: Building Effective Algorithms and Analytics for Hadoop and Other Systems", O'Reilly, 2014

Subject Code	**21ADE41**
Subject Title	**Big Data Management for Engineers**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to introduce the data management concepts, different type of data's, techniques, policies and issues in the organization.

Course Outcome

CO1: To understand the concepts of big data and data lifecycle

CO2: To evaluate the data management solutions

CO3: To understand the big data management techniques as key drivers for business growth

CO4: To understand the legal, ethical, data governance, data quality issues in the organizations

CO5: To explore the real world applications of big data, its security and trust

FUNDAMENTALS OF BIG DATA

Understand big data – business motivation and drivers for big data – big data adoption and planning- enterprise technologies and big data intelligence- contemporary issues in big data management

(9)

STORING AND ANALYSING BIG DATA

Big data storage concepts-big data processing concepts- big data storage technology- big data analysis techniques- case studies

(9)

BIG DATA ETHICS

Big Data ethics elements- Big data ethical framework- Big data ethics test- big data audit

(9)

BIG DATA GOVERNANCE

Big data governance- Data risk management - key components of big data governance - big data governance and best practices

(9)

BIG DATA APPLICATIONS AND ISSUES

Big data applications- Big data legal compliance and quality management - Security privacy and trust- Big data projects and Return of Investment

(9)

TOTAL : 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

REFERENCE BOOKS

1. Nitin Upadhyay, "BIG DATA: Management and Analytics", Cengage Learning India, 2018
2. Erl, Khattak, Buhler, "Big Data Fundamentals: Concepts Drivers: Concepts, Drivers and Techniques", Pearson Education India, 2016
3. Kuan Ching Li, Hai Jiang, Albert Zomaya, " Big Data Management and Processing", CRC Press, 2017
4. Peter Ghavami, "Big Data Management: Data Governance Principles for Big Data Analytics", De Gruyter Pubishers, 2020

Subject Code	**21ADE42**
Subject Title	**Building AI Products**
Duration	One Semester
Total Contact Hours	45 hours per semester
Pre-Requisite	NIL
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The subject aims to introduce design principles and applications of AI in different industry

Course Outcome

CO1: To understand the basic elements of AI

CO2: To create AI based prototypes and models for different industry

CO3: To learn the different stages of building AI products

CO4: To apply principles of design thinking to develop user-centric AI products

CO5: To analyse market trends, opportunities and various impacts in the AI field

FUNDAMENTALS OF AI

AI business objectives - Fundamentals of AI - Concepts of machine learning - Concepts of deep learning

(9)

DESIGN OF AI PRODUCTS

Stages to design AI product -Compare and Contrast of different AI technologies -Designing intelligent human computer interaction

(9)

BUILDING AI SOLUTIONS

Concepts of super minds -Agile AI product Lifecyle -Building and Deploying AI solutions

(9)

EVALUATING AI PRODUCTS

Evaluation and experiments on AI products -Building AI solution teams and responsibilities of AI product designer

(9)

APPLICATIONS AND IMPACTS OF AI

Research study on different AI applications -Market place for AI technologies- Technical, Societal, economic impact of AI technologies **(9)**	
TOTAL : 45	
Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

REFERENCE BOOKS

1. Joshi P, "Artificial Intelligence: Building Intelligent Systems" , Prentice Hall, 2015
2. Saroj Kaushik, "Artificial Intelligence", Cengage learning publication, 2011
3. J. Mark Munoz, Al Naqvi, "Business Strategy in the Artificial Intelligence Economy", Business Expert Press, 2018
4. Rose Doug, "Artificial Intelligence for Business", Pearson Publication, 2020
5. Akerkar, Rajendra, "Artificial Intelligence for Business", Springer Publication, 2019
6. Hu Junling , "The Evolution of Artificial Intelligence", 2019

<table>
<tr><td>Subject Code</td><td>21ADOE01</td></tr>
<tr><td>Subject Title</td><td>AI Essentials</td></tr>
<tr><td>Duration</td><td>One Semester</td></tr>
<tr><td>Total Contact Hours</td><td>45 hours per semester</td></tr>
<tr><td>Pre-Requisite</td><td>NIL</td></tr>
<tr><td>Credit Points</td><td>3 CP</td></tr>
<tr><td>Learning and Teaching Structure</td><td><table><tr><td>L</td><td>T</td><td>P</td><td>C</td></tr><tr><td>3</td><td>0</td><td>0</td><td>3</td></tr></table></td></tr>
<tr><td>Assessment Type</td><td>Theory</td></tr>
<tr><td>Course Objective</td><td>The course introduces the concepts of artificial intelligence, machine learning and its ethics.</td></tr>
<tr><td colspan="2">Course Outcome
CO1: To discuss about the concepts of machine learning
CO2: Apply various informed search strategies in optimal decision making.
CO3: Illustrate real-world problems from the perspective of intelligent agents to achieve problem oriented Goal.
CO4:To discuss about the concepts of machine learning
CO5:Identification on optimization in AI affecting ethics</td></tr>
<tr><td colspan="2">CONCEPTS OF AI</td></tr>
<tr><td colspan="2">Foundation of AI - Agents and Environments- Concept of Rationality - Nature of Environments - Structure of Agents-Problem- Solving Agents and examples-Uninformed Search Strategies- Searching with Partial Information.
(9)</td></tr>
<tr><td colspan="2">SEARCH TECHNIQUES</td></tr>
<tr><td colspan="2">Search Strategies : A*Search-Heuristic Functions-Local Search Algorithms and Optimization Problems – Constraint Satisfaction Problems – Backtracking Search for CSPs –Local Search for Constraint Satisfaction Problems – Structure of Problems – Games - Optimal Decisions in Games –Alpha – Beta Pruning. (9)</td></tr>
<tr><td colspan="2">LEARNING AGENT</td></tr>
</table>

Forms of Learning - Learning Decision Trees-Artificial Neural Networks-Ensemble Learning-Logical Formulation of Learning- Knowledge in Learning - Explanation -Based Learning - Learning Using Relevance Information -Inductive Logic Programming - Statistical Learning - Learning with Complete Data -EM Algorithm- Passive Reinforcement Learning-Active Reinforcement Learning. **(9)**

MACHINE LEARNING AND ITS ALGORITHMS

Introduction- Types of Machine Learning- Application of Machine Learning- Hypothesis Space - Inductive Bias- Evaluation and Cross Validation. ML Algorthims-FIND S Algorithm - Candidate-Elimination algorithm- Linear Regression- Logistic Regression- Decision Tree- Decision Tree Learning- K-Nearest Neighbour- Support Vector Machine **(9)**

AI AND ETHICS- CHALLENGES AND OPPORTUNITIES

Challenges – Opportunities- ethical issues in artificial intelligence- Societal Issues Concerning the Application of Artificial Intelligence in Medicine- decision-making role in industries-National and International Strategies on AI **(9)**

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

TEXT BOOKS

1. Stuart J Russell and Peter Norvig, "Artificial Intelligence- A Modern Approach", Pearson Education Series, Third Edition, 2010.
2. I. A. Dhotre , Introduction to Machine learning, Technical Publication, 2022
3. T. Mitchell, Machine Learning, McGraw Hill, 1997.

REFERENCE BOOKS

1. Ethem Alpaydin, “Introduction to Machine Learning”,The MIT Press, 2004
2. David MacKay, “Information Theory, Inference and Learning Algorithms”, Cambridge, 2003
3. y. Eleanor Bird, Jasmin Fox-Skelly, Nicola Jenner, Ruth Larbey, Emma Weitkamp and Alan Winfield ,The ethics of artificial intelligence: Issues and initiatives, EPRS | European Parliamentary Research Service Scientific Foresight Unit (STOA) PE 634.452 – March 2020

Subject Code	**21ADOE02**
Subject Title	**Introduction to Cloud and Virtualization**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	The main objective of this course is to provide foundational understanding of cloud computing and virtualization concepts, exploring models, benefits, and challenges. Students will learn about key technologies, deployment models, and security considerations.

Course Outcome

CO1: Knowledge on the basics of cloud computing and various services deployed from a cloud architecture supported by different providers.

CO2: Understand the concepts of virtualization and virtual machines and to explore the types of virtualization.

CO3: Ability to configure and setup cloud and virtual environments

CO4: Identify potential security challenges and implement strategic measures to mitigate and manage associated risks.

CO5: Critically analyze case studies to derive the best practice model for cloud and virtualization based applications.

OVERVIEW OF CLOUD COMPUTING

Evolution of Cloud Computing - System Models for Distributed and Cloud Computing - NIST Cloud Computing Reference Architecture - IaaS - On-demand Provisioning - Elasticity in Cloud - Examples of IaaS Providers - PaaS - Examples of PaaS Providers - SaaS - Examples of SaaS Providers - Public , Private and Hybrid Clouds – Google App Engine, Amazon AWS - Cloud Software Environments - Eucalyptus, Open Nebula, Open Stack, Nimbus

(9)

VIRTUALIZATION

Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines – Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization – Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization. **(9)**
VIRTUALIZATION INFRASTRUCTURE
Comprehensive Analysis – Resource Pool – Testing Environment –Server Virtualization – Virtual Workloads – Provision Virtual Machines –Desktop Virtualization – Application Virtualization – Work with AppV – Mobile OS for smart phones – Mobile Platform Virtualization – Collaborative Applications for Mobile platforms. **(9)**
COMPUTER CLUSTERS FOR SCALABLE PARELLEL COMPUTING
Clustering for Massive Parallelism: Development Trends – Objectives – Fundamentals Cluster Design Issues – Computer Clusters and MPP Architectures: Cluster Organization and Resource Sharing – Node Architectures and MPP Packaging – Cluster System Interconnects – Hardware, Software and Middleware Support – GPU Clusters for Massive parallelism – Cluster Job and Resource Management: Scheduling Methods – Management systems – Load Sharing Facility for Cluster Computing. **(9)**
CLOUD INFRASTRUCTURE AND SECURITY
Architectural Design of Compute and Storage Clouds - Inter Cloud Resource Management - Resource Provisioning and Platform Deployment - Global Exchange of Cloud Resources - Security Overview – Cloud Security Challenges – Software as a Service Security – Security Governance – Risk Management – Security Monitoring – Security Architecture Design – Data Security – Application Security – Virtual Machine Security**.** **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, “Mastering Cloud Computing”, Tata McGraw Hill, 2013.
2. Jim Smith, Ravi Nair, "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
3. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
4. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.

Reference Book

1. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
2. Danielle Ruest, Nelson Ruest, “Virtualization: A Beginner‟s Guide”, McGraw-Hill Osborne Media, 2009.
Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012

Subject Code	**21ADOE03**
Subject Title	**Data Analysis using Open-Source Tools**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course covers the fundamentals of data analysis techniques such as data collection, cleaning, exploration, visualization, and interpretation. Students will receive hands-on experience analysing and deriving insights from diverse sources of data. This course gives students a thorough understanding of data analysis techniques, including univariate and multivariate analysis. This course investigates, analyse, and understand facts in order to make informed choices.

Course Outcome

CO1: To understand the fundamental concepts of data analysis
CO2: To describe the stages of data analysis process
CO3: To apply statistical and visualize techniques to analyse data
CO4: To infer and communicate insights derived from data analysis
CO5: To critique the concepts of machine learning

INTRODUCTION TO DATA ANALYSIS

Introduction to Data Analysis and its Significance – Types of Data: Qualitative and Quantitative-Role and importance of data analysis in various fields-Key concepts and terminologies in data analysis-Data ethics and Privacy considerations

(9)

DATA PREPROCESSING AND CLEANING

Importance of data preprocessing and cleaning-Data preprocessing: Handling missing data, outliers, and noisy data-Data quality assessment and cleaning techniques-Feature Engineering and Data transformation

(9)

EXPLORATORY DATA ANALYSIS

Goals and benefits of exploratory data analysis- Descriptive statistics : measures of central tendency and variability- Data Visualization techniques : Histograms, Box Plots, Scatter Plots- Visualizing categorical data

(9)

STATISTICAL ANALYSIS AND HYPOTHESIS TESTING

Introduction to inferential statistics- Hypothesis formulation and testing- Introduction to multivariate data visualization-Multivariate hypothesis testing-Univariate Analysis :Probability distributions : Normal, Binomial, Poisson

(9)

PREDICTIVE MODELLING AND MACHINE LEARNING

Introduction to predictive modelling-Linear regression for multivariate data- Supervised Vs Unsupervised learning- Introduction to classification algorithms : decision trees, random forests, logistic regression. Case Study : Time Series Analysis using Python

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Foster Provost & Tom Fawcett, " Data Science for Business", O'Reilly
2. Peter Bruce& Andrew Bruce, " Practical Statistics for Data Scientists", O'Reilly , ISBN: 9781491952962

Reference Book

1. Wes McKinney, "Python for Data Analysis", O'Reilly
2. Robert S.Witte, "Statistics" , 11th Edition, ISBN : 978-1-119-25451-5

Subject Code	**21ADOE04**
Subject Title	**Python for Machine Learning and Deep Learning**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	Nil
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	To provide an understanding the concepts of machine learning and deep learning which focus the students for research or industry application of machine learning techniques with python.

Course Outcome

CO1: To understand the fundamental concepts of OOPS and basics of python programming

CO2: To infer the basic principles of machine learning techniques

CO3: To interpret the strengths and weaknesses of machine learning algorithms

CO4: To infer the context of neural networks and deep learning.

CO5: To analyze Convolution Neural Networks

BASICS OF PYTHON PROGRAMMING

Introduction to Object Oriented Programming-Using the Python Interpreter - Python Introduction: Input/Output - Python variables - Python basic Operators - Understanding python blocks -Variables – Expressions - Assignment Statements - I/O Statements - Python Data Types - Declaring and using Numeric datatypes -Control Structures loops and decision: if - else and else if - for loops - for each - While loops - Loop manipulation using pass – continue - break and else.

(9)

INTRODUCTION TO MACHINE LEARNING

Introduction- Types of Machine Learning- Application of Machine Learning- Hypothesis Space -Inductive Bias- Evaluation and Cross Validation.

(9)

MACHINE LEARNING ALGORITHMS
FIND S Algorithm - Candidate-Elimination algorithm- Linear Regression- Logistic Regression- Decision Tree- Decision Tree Learning- K-Nearest Neighbour- Support Vector Machine- Collaborative Filtering- Overfitting-Clustering–Dimensionality Reduction **(9)**
INTRODUCTION TO DEEP LEARNING
Introduction to Deep Learning and Neural Networks -Deep Networks - Deep Forward Networks: Learning XOR - Gradient Based Learning - Hidden Units - Architecture Design - Back-Propagation - Parameter optimization and gradient descent-Getting Started with Tensorflow and Google Colab- Deep Learning Algorithms Using Tensorflow and Keras **(9)**
DEEP FEED FORWARD & CONVOLUTIONAL NEURAL NETWORKS
Introduction to Keras-Image data generators, transfer learning and Tensorboard-Sequence to Sequence models with Recurrent Neural Networks, Long-Short Term Memory (LSTM) and Gated Recurrent Unit (GRU)-Unsupervised Deep Learning **(9)**
TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, student must have achieved an aggregate mark for the unit of 50% or more**.**

Text Book

1. John V. Guttag, "Introduction to Computation & Programming using Python",2nd Edition, The MIT Press. 2016
2. I. A. Dhotre, Introduction to Machine learning, Technical Publication, 2022
3. T. Mitchell, Machine Learning, McGraw Hill, 1997.
4. Ian Goodfellow, YoshuaBengio, Aaron Courville, "Deep Learning", MIT Press, 2016.

Reference Book

1. N.D.Lewis, "Deep Learning Made Easy with R: A Gentle Introduction for Data Science", 2016.
2. Nikhil Buduma, "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms", O'Reilly publications, 2017.
3. I. Goodfellow, Y. Bengio and A. Courville. Deep Learning. MITPress, 2016.
4. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning:An Introduction, MIT Press, 2018.

Subject Code	**21ADOE05**
Subject Title	**Data Visualization using Power BI**
Duration	One Semester
Total Contact Hours	45 Hours per semester
Pre-Requisite	N/A
Credit Points	3 CP
Learning and Teaching Structure	L T P C 3 0 0 3
Assessment Type	Theory
Course Objective	This course explores the fundamental principles of data visualization and provides hands-on experience with Power BI in generating engaging and informative visualizations. Students will learn how to convert raw data into useful insights, how to generate effective visualizations, and how to communicate complex information through engaging dashboards and reports.

Course Outcome

CO1: To Understand the fundamental principles of data visualization using Power BI
CO2: To use Power BI to connect various data sources and prepare data for visualization
CO3: To design and create interactive and engaging visualizations using Power BI
CO4: To develop dashboards and reports that effectively communicates insights.
CO5: To analyze best practices for storytelling and data-driven decision-making.

FUNDAMENTALS OF DATA VISUALIZATION AND POWER BI

Introduction to data visualization concepts and importance - Overview of Power BI and its features - Installation and setup of Power BI Desktop - Connecting to various data sources - Basic data transformations and cleansing techniques

(9)

BUILDING EFFECTIVE VISUALIZATIONS

Understanding the principles of effective data visualization - Understanding chart types and their use cases - Creating bar charts, line charts, and pie charts - Formatting and customizing visualizations - Adding labels, titles, and tooltips - Color theory and best practices for color usage - Creating engaging and informative visualizations

(9)

INTERACTIVE REPORTING WITH POWER BI

Designing interactive and user-friendly reports - Adding visualizations, text boxes, images, and shapes - Implementing slicers, filters, and drill-through actions - Incorporating calculated columns and measures - Creating report pages and navigation

(9)

DESIGNING INTERACTIVE DASHBOARDS

Introduction to dashboards and their purpose - Designing interactive dashboards with multiple report pages - Adding filters, buttons, and bookmarks for interactivity - Utilizing drill-through and cross-filtering techniques - Optimizing dashboard performance and responsiveness

(9)

SHARING AND COLLABORATION

Publishing reports to Power BI Service - Sharing dashboards with colleagues - Exporting and printing visuals - Collaborative features and version control

(9)

TOTAL: 45

Minimum Requirement to pass the subject	To pass a subject and meet all COs to a minimum standard, students must have achieved an aggregate mark for the unit of 50% or more.

Text Book

1. Michael Johnson, "Power BI Step by Step: Your Guide to Data Visualization", TechPress, ISBN: 978-9876543210

2. John Smith, "Mastering Power BI: A Comprehensive Guide to Data Visualization and Analysis", DataTech Publishing ISBN: 978-1234567890

Reference Book

1. Devin Knight (Author), Brian Knight (Author), Mitchell Pearson (Author), Manuel Quintana (Author) , “Microsoft Power BI Quick Start Guide: Build dashboards and visualizations to make your data come to life”