B. Tech. Degree

in

COMPUTER SCIENCE AND ENGINEERING

SYLLABUS FOR FLEXIBLE CURRICULUM

(For students admitted in 2024-25)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA.

VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

- To evolve as an internationally recognised centre of excellence for teaching and research in computer science and engineering with societal and industry relevance.

MISSION OF THE DEPARTMENT

- To offer multidisciplinary and interdisciplinary undergraduate, postgraduate and research programmes with focus on societal research and industrial needs.
- To provide a conducive environment for learning, leading to be efficient employee's and successful entrepreneurs.
- To establish strong and solution-oriented industry academia binding for sustainable growth.
- To inculcate ethical values for holistic nation building.

GRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates are prepared to be employed in IT industries and be engaged in continuous learning, understanding, and applying new ideas.
PEO2	Graduates are prepared to take up Masters and Research programmes.
PEO3	Graduates are prepared to be responsible computing professionals in their own area of interest solving societal problems and be successful entrepreneurs.

PROGRAMME OUTCOMES (POs)

PO1	Ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modelling and design of computer based systems.
PO2	Ability to analyse existing literature in computer science and suggest modification to algorithms and create new algorithms for solving engineering problems.
PO3	Ability to apply the computing knowledge and propose solutions in domain such as health care, banking, finance, agriculture and other allied professions.
PO4	Ability to design software systems based on interpreting available data in all societal and engineering domains and analyse their performance.
PO5	Ability to analyse the problem, subdivide into smaller tasks with well-defined interface for interaction among components, and complete within the specified time frame and domain constraints.
PO6	Ability to propose original ideas and solutions, culminating into a modern, easy to use tool, by a larger section of the society with longevity.
PO7	Ability to design, implement, and evaluate secure hardware and integrate with software assuring quality and efficiency.
PO8	Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the computer science and engineering practices.
PO9	Ability to modularize the problem statement, allocate to individuals and function effectively as an individual and a team player.
PO10	Ability to communicate effectively the engineering solution to customers/users or peers by means of sufficient and necessary documentation.
PO11	Ability to demonstrate knowledge and understanding of computer science and engineering principles and apply these to individual's and team work.
PO12	Ability to understand contemporary issues and to get engaged in lifelong learning by independently and continually expanding knowledge and abilities.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	Ability to design and develop effective solutions based on state-of-the-art hardware and efficient software with a blend of creativity and performance.
PSO2	Ability to pursue higher studies in a multidisciplinary perspective leading to Masters and Research degrees.
PSO3	Ability to apply the Computer Science and Engineering concepts in different fields of Engineering culminating in successful careers and entrepreneurs with a focus on societal problem solving.

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR YEAR B.Tech. & THREE YEAR B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	23	56	34.7
PC (Programme Core)	15	52 – 55**	33.1
Programme Elective (PE) / Open Elective (OE)	12	36	22.3
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.9
Total	**58**	**160+3**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).
2. Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).
3. For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the departments (160 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.
4. To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.
5. Project work is compulsory for B. Tech. programme. However, those students wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech. (CSE)

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	8	19	-	-	-	-	-	-	**19**	**40**
II	8	17	1	4	-	-	-	-	**21**	
III	1	4	4	13	2	4	1	3	**24**	**47**
IV	1	3	3	10	2	4	2	6	**23**	
V	1	3	4	14	2	4	1	3	**24**	**49**
VI	1	1	3	11	2	4	3	9	**25**	
VII	2	3	-	-	-	-	4	12	**15**	**24**
VIII	1	6	-	-	-	-	1	3	**9**	
Total	**23**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	8	19	-	-	-	-	-	-	**19**	**40**
	II	8	17	1	4	-	-	-	-	**21**	
	III	1	4	4	13	2	4	1	3	**24**	**47**
	IV	1	3	3	10	2	4	2	6	**23**	
B.Sc. Exit	**V**	1	3	2	6	2	4	1	3	**16**	**33**
	VI	3[@]	9	1	3	1	2	1	3	**17***	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	2	8	-	-	4	12	**20**	**40**
	VIII	1	1	2	8	1	2	3	9	**20**	
	Total	**23**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

[@](Summer internship (2), Project Work (6) and Industrial Lecture (1))

GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES

Sl. No.	Course	Number of Courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1	3
	Physics Laboratory	1	2
3.	Chemistry	1	3
	Chemistry Laboratory	1	2
4.	Industrial Economics and Foreign Trade	1	3
5.	English for Communication (Theory & Lab)	2	4
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course (Introduction to the Branch of study)	1	2
13.	Summer Internship	1	2
14.	Project work	1	6
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Pass / Fail
Total		**23**	**56**

Curriculum Framework and Credit System (CS)

Semester I (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	MAIR12	Mathematics I / Linear Algebra and Calculus	3	GIR
2.	PHIR11	Physics	3	GIR
3.	ENIR11	Energy and Environmental Engineering	2	GIR
4.	CSIR11	Introduction to Computer Programming (T + L)	3	GIR
5.	CEIR11	Basics of Civil Engineering	2	GIR
6.	MEIR11	Basics of Mechanical Engineering	2	GIR
7.	PRIR11	Engineering Practice	2	GIR
8.	PHIR12	Physics Laboratory	2	GIR
		Total	**19**	

Semester II (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	HSIR11	English for Communication (Theory & Lab)	4	GIR
2.	MAIR22	Mathematics II / Complex Analysis and Differential Equations	3	GIR
3.	CHIR11	Chemistry	3	GIR
4.	CSIR15	Branch Specific Course (Essentials of Computer Science)	2	GIR
5.	MEIR12	Engineering Graphics	3	GIR
6.	CHIR12	Chemistry Laboratory	2	GIR
7.	SWIR11	NSS/NCC/NSO	0	GIR
8.	CSPC11	Programme Core – I / Discrete Structures	4	PC
		Total	**21**	

Semester III (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	MAIR31	Mathematics III / Probability & Operations Research	4	GIR
2.	CSPC31	Programme Core II / Principles of Programming Languages	4	PC
3.	CSPC32	Programme Core III / Data Structures	3	PC
4.	CSPC33	Programme Core IV / Digital Systems Design	3	PC
5.	CSPC34	Programme Core V / Computer Organization	3	PC
6.		Programme Elective – I	3	PE
7.	CSLR31	Laboratory I / Data structures Laboratory	2	ELR
8.	CSLR32	Laboratory II / Digital Laboratory	2	ELR
		Total	**24**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 24 credits.

Semester IV (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	CSIR41	Professional Ethics	3	GIR
2.	CSPC41	Programme Core VI / Formal Languages and Automata Theory	4	PC
3.	CSPC42	Programme Core VII / Design and Analysis of Algorithms	3	PC
4.	CSPC43	Programme Core VIII / Operating Systems	3	PC
5.		Programme Elective – II	3	PE
6.		Programme Elective – III / Open Elective – I	3	PE/OE
7.	CSLR41	Laboratory III / Algorithms Laboratory	2	ELR
8.	CSLR42	Laboratory IV / Operating Systems Lab	2	ELR
		Total	**23**	

Semester V (July Session) / Continuing B.Tech.

Sl. No.	Course Code	Course	Credits	Category
1.	HSIR13	Industrial Economics	3	GIR
2.	CSPC51	Programme Core IX / Computer Architecture	4	PC
3.	CSPC52	Programme Core X / Database Management Systems	3	PC
4.	CSPC53	Programme Core XI / Computer Networks	3	PC
5.	CSPC54	Programme Core XII / Introduction to Artificial Intelligence and Machine Learning	4	PC
6.		Programme Elective – IV / Open Elective – II	3	PE
7.	CSLR51	Laboratory V / Database Management Systems Laboratory	2	ELR
8.	CSLR52	Laboratory VI / Networks Laboratory	2	ELR
		Total	**24**	

Semester VI (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	CSIR61	Industrial Lecture	1	GIR
2.	CSPC61	Programme Core XIII / Embedded Systems Architectures	3	PC
3.	CSPC62	Programme Core XIV / Compiler Design	4	PC
4.	CSPC63	Programme Core XV / Principles of Cryptography	4	PC
5.		Programme Elective – V	3	PE
6.		Programme Elective – VI	3	PE
7.		Programme Elective – VII / Open Elective – III	3	PE/OE
8.	CSLR61	Laboratory VII / Embedded Systems Laboratory	2	ELR
9.	CSLR62	Laboratory VIII / App Development Laboratory	2	ELR
		Total	**25**	

Semester VII (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	CSIR71	Summer Internship	2	GIR
2.	CSIR72	Comprehensive Viva Voce	1	GIR
3.		Programme Elective – VIII	3	PE
4.		Programme Elective – IX	3	PE
5.		Programme Elective – X / Open Elective – IV	3	PE/OE
6.		Programme Elective – XI / Open Elective – V	3	PE/OE
		Total	**15**	

Semester VIII (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.		Programme Elective – XII / Open Elective – VI	3	PE/OE
2.	CSIR81	Project Work	6	GIR
		Total	**9**	

Semester V (July Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course	Credits	Category
1.	CSIR61	Industrial Lecture	3	GIR
2.	CSPC51	Programme Core IX / Database Management Systems	3	PC
3.	CSPC52	Programme Core X / Computer Networks	3	PC
4.		Programme Elective – IV / Open Elective – II	3	PE/OE
5.	CSLR51	Laboratory V / Database Management Systems Laboratory	2	ELR
6.	CSLR52	Laboratory VI / Networks Laboratory	2	ELR
		Total	**16**	

Semester VI (January Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course	Credits	Category
1.	CSIR81	Project Work	6	GIR
2.	CSIR71	Winter Internship	2	GIR
3.	CSIR61	Industrial Lecture	1	GIR
4.		Programme Core – XI / Embedded Systems Architectures	3	PC
5.		Programme Elective – V	3	PE
6.	CSLR61	Laboratory – VII / Embedded Systems Laboratory	2	ELR
		Total	**17**	

Semester VII (July Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course	Credits	Category
1.	CSPC54	Programme Core – XII / Introduction to Artificial Intelligence and Machine Learning	4	PC
2.	CSPC51	Programme Core – XIII / Computer Architecture	4	PC
3.		Programme Elective – VI	3	PE
4.		Programme Elective – VII	3	PE
5.		Programme Elective – VIII	3	PE
6.		Programme Elective – IX / Open Elective – III	3	PE/OE
		Total	**20**	

Semester VIII (January Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course	Credits	Category
1.	CSPC62	Programme Core – XIV / Compiler Design	4	PC
2.	CSPC63	Programme Core – XV / Principles of Cryptography	4	PC
3.		Programme Elective – X	3	PE
4.		Programme Elective – XI / Open Elective – IV	3	PE
5.		Programme Elective – XII / Open Elective – V	3	PE/OE
6.		Laboratory – VIII	2	ELR
7.		Comprehensive Viva Voce	1	GIR
		Total	**20**	

Credits

Semester	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech.	**19**	**21**	**24**	**23**	**24**	**25**	**15**	**9**	**160**
B.Sc.	**19**	**21**	**24**	**23**	**16**	**17**	**20**	**20**	**160**

Note:

1. Curriculum should have 7 Programme Core courses shall be of 4 credits each.
2. Out of 12 elective courses (PE/OE), the students should study at least eight programme elective courses (PE).
3. Minor (MI): 15 credits over and above the minimum credit as specified by the departments (160). The details of MINOR will be mentioned in the transcript and in the Degree certificate.
4. Honours (HO): 15 credits over and above the minimum credit as specified by the departments (160).

ELECTIVES CHOICES

Option 1 / Regular B.Tech.

To get a B.Tech. degree in Computer Science & Engineering, possible choices of electives in ProgrammeElectives and Open Electives are,

Program Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Program Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in Computer Science & Engineering, and minor in other programmes, possiblechoices of electives in Programme Electives, Open Electives and Minor Electives are,

Program Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honours

To get a B.Tech. Honors degree in Computer Science & Engineering, possible choices of electives inProgramme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honours and Minor

To get a B.Tech. Honors degree in Computer Science & Engineering, and minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honours will be awarded for B.Sc. But student can credit minors and honours during the 6 semesters, and redeem it to obtain a minor or honours after rejoining and completing B.Tech. Also, B.Sc. students shall only do programme electives in place of their project work in 6th semester.

LIST OF COURSES

GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES

Sl. No.	Course Code	Course	Credits
1.	MAIR12	Mathematics I - Linear Algebra and Calculus	3
2.	PHIR11	Physics	3
3.	PHIR12	Physics Laboratory	2
4.	ENIR11	Energy and Environmental Engineering	2
5.	CSIR11	Introduction to Computer Programming (Theory & Lab)	3
6.	CEIR11	Basics of Civil Engineering	2
7.	MEIR11	Basics of Mechanical Engineering	2
8.	PRIR11	Engineering Practice	2
9.	HSIR11 & HSIR12	English for Communication (Theory & Lab)	4
10.			
11.	MAIR22	Mathematics II - Complex Analysis and Differential Equations	3
12.	CHIR11	Chemistry	3
13.	CHIR12	Chemistry Laboratory	2
14.	CSIR15	Branch Specific Course – Essentails of Computer Science	2
15.	MEIR12	Engineering Graphics	3
16.	SWIR11	NSS/NCC/NSO	0
17.	MAIR31	Mathematics III – Probability & Operations Research	4
18.	CSIR41	Professional Ethics	3
19.	HSIR13	Industrial Economics and Foreign Trades	3
20.	CSIR61	Industrial Lecture	1
21.	CSIR71	Summer Internship	2
22.	CSIR72	Comprehensive Viva Voce	1
23.	CSIR81	Project Work	6
		Total	**56**

(I) PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPC11	Programme Core I / Discrete Structures	-	4
2.	CSPC31	Programme Core II / Principles of Programming Languages	-	4
3.	CSPC32	Programme Core III / Data Structures	-	3
4.	CSPC33	Programme Core IV / Digital Systems Design	-	3
5.	CSPC34	Programme Core V / Computer Organization	-	3
6.	CSPC41	Programme Core VI / Formal Languages and Automata Theory	CSPC11	4
7.	CSPC42	Programme Core VII / Design and Analysis of Algorithms	CSPC32	3
8.	CSPC43	Programme Core VIII / Operating Systems	-	3
9.	CSPC51	Programme Core IX / Computer Architecture	CSPC34	4
10.	CSPC52	Programme Core X / Database Management Systems	-	3
11.	CSPC53	Programme Core XI / Computer Networks	-	3
12.	CSPC54	Programme Core XII / Introduction to Artificial Intelligence and Machine Learning	CSPC11	4
13.	CSPC61	Programme Core XIII / Embedded Systems Architectures	CSPC51	3
14.	CSPC62	Programme Core XIV / Compiler Design	CSPC41	4
15.	CSPC63	Programme Core XV / Principles of Cryptography	-	4
			Total	**52**

(II) ELECTIVES

a. PROGRAMME ELECTIVES

II Year Electives (Programme Elective – I, II, III)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE01	Combinatorics and Graph Theory	CSPC11	3
2.	CSPE02	Software Engineering	-	3
3.	CSPE03	Design Thinking	-	3
4.	CSPE04	Advanced Data Structures and Algorithms	CSPC32	3
5.	CSPE05	Multimedia Systems	-	3
6.	CSPE06	Computing algorithms based on Indian Knowledge Systems	-	3

Stream I: Modern Computing Paradigms

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE11	Real Time Systems	CSPC43	3
2.	CSPE12	Cloud Computing	CSPC43	3
3.	CSPE13	Design and Analysis of Parallel Algorithms	CSPC42	3
4.	CSPE14	Parallel Architectures and Programming	CSPC51	3
5.	CSPE15	GPU Computing	CSPC51	3
6.	CSPE16	Internet of Things - Principles and Practices	-	3
7.	CSPE17	Quantum Computing	-	3

Stream II: Network and Security

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE21	Cyber Physical Systems	-	3
2.	CSPE22	Internetworking Protocols	-	3
3.	CSPE23	Network Security	CSPC63	3
4.	CSPE24	Wireless Network Systems	CSPC53	3
5.	CSPE25	Advanced Cryptography	CSPC63	3
6.	CSPE26	Information Security	-	3
7.	CSPE27	Metaverse and Blockchain	-	3

Stream III: Artificial Intelligence and Applications

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE31	Image Processing and Applications	-	3
2.	CSPE32	Machine Learning Techniques and Practices	CSPC54	3
3.	CSPE33	Deep Learning Techniques	CSPC54	3
4.	CSPE34	Natural Language Processing	CSPC62	3
5.	CSPE35	Deep Learning Paradigms for Computer Vision	CSPC54	3
6.	CSPE36	Responsible & Ethical AI	-	3
7.	CSPE37	Generative AI	-	3
8.	CSPE38	Cognitive Science	-	3
9.	CSPE39	Drone Technologies	-	3

Stream IV: Software Engineering for Web Applications

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE41	Augmented and Virtual Reality	-	3
2.	CSPE42	Game Theory	-	3
3.	CSPE43	Software Testing and Automation	-	3
4.	CSPE44	Agile Software Development	-	3
5.	CSPE45	Web Technology and its Applications	-	3
6.	CSPE46	Brain Computer Interface and its Applications	-	3
7.	CSPE47	Full Stack development	CSPC52	3
8.	CSPE48	DevOps	CSPC62	3

Stream V: Data Engineering

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSPE51	Data Interpretation and Analysis	-	3
2.	CSPE52	Advanced Database Management Systems	CSPC52	3
3.	CSPE53	Data Analytics	-	3
4.	CSPE54	Data Science	-	3
5.	CSPE55	Social Network Analysis	-	3
6.	CSPE56	Human Computer Interaction	-	3
7.	CSPE57	Text, Speech and Video Analytics	-	3

Note:

1. Programme electives (PE1, PE2, PE3) have to be chosen from the Second year elective group.
2. Programme electives for 5^{th} to 8^{th} semester can be chosen from the streams.
3. If a student chooses at least 6 Programme electives from a particular stream then the stream will be mentioned as the specification in their transcript.

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Computer Science and Engineering for students of all Departments.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSOE11	Big Data Analytics	-	3
2.	CSOE12	Cloud & Grid Computing	-	3
3.	CSOE13	Computer Graphics and Multimedia Systems	-	3
4.	CSOE14	Distributed Architecture	-	3
5.	CSOE15	Human Computer Interaction	-	3
6.	CSOE16	Image Processing	-	3
7.	CSOE17	Internet of Things	-	3
8.	CSOE18	Machine Learning for Engineering Applications	-	3
9.	CSOE19	Security Principles	-	3
10.	CSOE20	Soft Computing	-	3
11.	CSOE21	Software Project Management	-	3
12.	CSOE22	Software Testing & Practices	-	3
13.	CSOE23	Web Technology	-	3

c. MINOR (MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in Computer Science and Engineering can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSMI11	Data Structures and Algorithms	-	3
2.	CSMI12	Computer Organization	-	3
3.	CSMI13	Operating Systems	-	3
4.	CSMI14	Database Management Systems	-	3
5.	CSMI15	Software Engineering	-	3
6.	CSMI16	Computer Networks	-	3
7.	CSMI17	Artificial Intelligence	-	3
8.	CSMI18	Internetworking Principles	-	3
9.	CSMI19	Web Application Development	-	3

(III) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSLR31	Laboratory I / Data structures Laboratory	-	2
2.	CSLR32	Laboratory II / Digital Laboratory	-	2
3.	CSLR41	Laboratory III / Algorithms Laboratory	-	2
4.	CSLR42	Laboratory IV / Operating Systems Lab	-	2
5.	CSLR51	Laboratory V / Database Management Systems Laboratory	-	2
6.	CSLR52	Laboratory VI / Networks Laboratory	-	2
7.	CSLR61	Laboratory VII / Embedded Systems Laboratory	-	2
8.	CSLR62	Laboratory VIII / App Development Laboratory	-	2

IV. ONLINE COURSES (OC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSOC01	Ethical Hacking	As per the NPTEL	3
2.	CSOC03	Foundations of Cyber Physical Systems	As per the NPTEL	3
3.	CSOC04	Privacy and Security in Online Social Media	As per the NPTEL	3
4.	CSOC05	Reinforcement Learning	As per the NPTEL	3
5.	CSOC06	C-Based VLSI Design	As per the NPTEL	3
6.	CSOC07	Approximation Algorithm	As per the NPTEL	3
7.	CSOC08	Deep Learning for Computer Vision	As per the NPTEL	3

Course list shall be updated regularly at the start of each Academic Year or Semester by the department NPTEL Coordinator. The students shall be able to select an online course from then available list.

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	CSHO11	Software Defined Networking	-	3
2.	CSHO12	Multi-Core Programming	CSPC51	4
3.	CSHO13	Pervasive and Ubiquitous Computing	CSPC43	3
4.	CSHO14	Virtualization Techniques	-	3
5.	CSHO15	Randomized Algorithms	CSPC42	4
6.	CSHO16	Compiler Optimization Techniques	CSPC41	4
7.	CSHO17	Fog and Edge Computing	-	4
8.	CSHO18	Quantum Safe Cryptography	CSPC63	4

VI. MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Sl. No.	Course Code	Course Title	Credit
1.	CSMCXX	*Offered based on the industry expert availability and recent trends*	1

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE (PC)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSPC11	Discrete Structures	CO1	Distinguish between the notion of discrete and continuous mathematical structures	3	3	0	2	2	0	0	0	0	0	0	2
		CO2	Prove basic set equalities	3	3	0	2	2	0	0	0	0	0	0	0
		CO3	Apply induction and other proof techniques towards problem solving	3	3	0	2	0	0	0	0	0	0	0	2
		CO4	Solve problems in Computer Science using graphs and trees	3	3	2	2	0	0	0	0	0	0	0	3
CSPC31	Principles of Programming Languages	CO1	Define data types, functions, syntax and semantics of all programming languages	2	2	0	0	0	0	0	0	0	0	0	0
		CO2	Use the various styles of programming languages for any given problem	0	0	1	1	0	2	0	0	0	0	0	0
		CO3	Compare and use appropriate parameter passing technique for solving problems	0	2	0	0	3	0	0	0	2	0	0	0
		CO4	Distinguish between the usage of all programming languages	3	0	0	0	0	0	0	0	0	1	0	1

CSPC32	Data Structures	CO1	Apply appropriate linear data structures such as stacks, queues, and linked lists in various applications.	3	2	0	0	0	0	0	0	0	0	0	0
		CO2	Apply the concept of trees and graph data structures in real world scenarios	3	0	1	0	0	0	0	0	0	0	0	0
		CO3	Appropriately to decide on the data structure for any practical problem	3	2	1	1	0	2	0	0	0	0	2	0
		CO4	Comprehend the implementation of sorting and searching algorithms	3	0	1	1	2	0	0	0	2	0	0	1
CSPC33	Digital Systems Design	CO1	Design a VLSI circuit for an application	3	0	1	0	2	2	2	0	0	0	0	1
		CO2	Comprehend the digital design logic	2	0	1	0	0	0	2	0	0	0	0	0
		CO3	Design and Analysis of a given digital circuit – combinational and sequential	3	0	0	0	0	0	2	0	0	0	0	1
		CO4	Use Boolean simplification techniques to design a combinational hardware circuit	2	0	0	0	2	0	2	0	0	0	0	0
CSPC34	Computer Organization	CO1	Understand the architecture and functionality of central processing unit	2	3	2	0	0	0	2	0	0	0	0	0
		CO2	Analyze the hardware and software issues and the interfacing	0	0	2	0	0	0	3	0	0	0	0	0

		CO3	Work out the trade-offs involved in designing a modern computer system	0	0	3	0	2	0	0	0	0	0	0	0
		CO4	Understand the various memory systems and I/O communication	3	3	0	0	1	0	2	0	0	2	0	3
CSPC41	Formal Languages and Automata Theory	CO1	Design finite automata or regular expression for any tokenization task	3	0	2	0	3	0	2	0	3	0	0	0
		CO2	Construct a context free grammar for parsing any language	3	0	2	0	0	2	1	0	0	0	3	3
		CO3	Design Turing machine and Conclude the decidable / undecidable nature of any language	3	0	1	0	0	1	1	0	0	0	0	0
		CO4	Apply mathematical and formal techniques for solving real-world problems	3	0	0	0	3	0	0	3	0	0	3	0
CSPC42	Design and Analysis of Algorithms	CO1	Analyze the time and space complexity for any algorithm	3	2	1	0	2	0	0	0	2	0	2	0
		CO2	Apply the design techniques of algorithm in solving real world problems	3	2	1	0	2	2	0	1	0	0	2	1
		CO3	Design randomized and dynamic programming based algorithms	3	2	0	0	2	3	0	0	0	0	2	0
		CO4	Understand NP class of problems and propose approximation algorithms for the same	3	2	0	0	0	2	0	0	0	0	0	1

CSPC43	Operating Systems	CO1	Comprehend the techniques used to implement the process manager.	3	0	3	0	3	0	2	0	0	0	2	0
		CO2	Comprehend memory management techniques.	2	1	3	1	0	0	2	0	0	0	0	1
		CO3	Design and develop file system and I/O system.	3	2	3	2	0	0	2	0	0	0	2	1
		CO4	Design & develop OS modules for distributed Environment.	3	0	0	0	0	1	3	0	0	2	2	2
CSPC51	Computer Architecture	CO1	Apply performance metrics to find the performance of systems.	3	0	3	0	0	0	2	0	0	3	0	0
		CO2	Identify the program block that requires parallelism for any program.	3	0	2	0	3	0	3	0	0	0	0	3
		CO3	Comprehend and differentiate various computer architectures and hardware.	3	0	0	0	0	0	3	0	0	0	0	0
		CO4	Design algorithms for memory management techniques and analyse the performance of a system	3	3	0	2	2	2	0	3	0	2	2	3
CSPC52	Database Management Systems	CO1	Master the basics of SQL and construct queries using SQL	2	2	0	0	0	0	0	0	0	0	0	0
		CO2	Design and develop a large database with optimal query processing	2	0	3	3	2	3	0	1	2	0	2	1

		CO3	Develop efficient storage scheme of saving and retrieving Records &Files	2	2	2	2	2	3	0	1	2	0	2	1
		CO4	Design the database with normalization techniques	0	0	0	2	1	1	1	1	1	1	2	1
CSPC53	Computer Networks	CO1	Gain insight about basic network theory and layered communication architectures.	3	0	0	0	0	0	0	3	0	3	0	0
		CO2	Able to resolve the medium access and routing problems under various scenarios	0	3	0	0	3	0	0	0	2	0	0	2
		CO3	Implement TCP and UDP protocols with better QoS support for the real time applications	0	0	3	3	0	2	0	0	0	0	0	3
		CO4	Propose algorithms at the appropriate layer for any communication network task	0	3	0	3	0	0	0	0	0	0	0	0
CSPC54	Introduction to Artificial Intelligence and Machine Learning	CO1	Suggest appropriate search strategies for any AI problem	3	2	3	0	3	0	0	0	3	0	0	0
		CO2	Design agents for any given problem	3	0	3	2	0	3	0	0	0	0	0	0
		CO3	Represent real world knowledge using 1st order or propositional logic	2	2	3	0	0	0	0	0	0	0	0	0
		CO4	Solve problems by appropriated using the supervised or unsupervised machine learning algorithms	3	0	3	0	0	0	0	0	0	0	0	0

CSPC61	Embedded Systems Architectures	CO1	Ability to comprehend the architecture of Embedded systems	0	1	0	0	0	0	2	2	0	0	2	2
		CO2	Ability to design and develop programs for specific embedded applications	3	0	1	1	3	3	2	0	0	0	0	1
		CO3	Understand operating systems for embedded systems	3	0	1	1	0	0	0	0	0	2	0	1
		CO4	Understand about life cycle of embedded design and its testing	0	2	0	0	1	0	0	0	0	1	0	0
CSPC62	Compiler Design	CO1	Apply the knowledge of LEX & YACC tool to develop a scanner and parser	2	0	1	0	0	3	0	0	0	3	0	2
		CO2	Design and develop software system for backend of the compiler	1	0	2	3	0	0	0	0	0	3	0	0
		CO3	Suggest the necessity for appropriate code optimization techniques	2	0	2	0	0	0	0	2	0	3	1	2
		CO4	Conclude the appropriate code generator algorithm for a given source language	0	1	0	2	0	3	0	2	0	0	2	2
CSPC63	Principles of Cryptography	CO1	Understand the basic concepts of symmetric cryptosystem, public key cryptosystem and digital signature scheme	3	0	3	0	0	3	2	0	0	0	0	0

		CO2	Evaluate the security of a protocol based on security metrics	3	0	3	0	3	3	0	0	0	0	0	0
		CO3	Justify the usage of security principles and digital signatures for any application	0	1	0	3	1	0	1	0	0	2	1	2
		CO4	Ability to break the cryptosystem that is secure	0	0	1	0	0	2	0	3	1	0	0	0

3 - High; 2 - Medium; 1 – Low

PROGRAMME ELECTIVES (PE)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSPE01	Combinatorics and Graph Theory	CO1	Comprehend the fundamentals of combinatorics and apply combinatorial ideas in mathematical arguments in analysis of algorithms, queuing theory,etc.	2	2	1	0	0	2	0	0	0	0	0	0
		CO2	Comprehend graph theory fundamentals and tackle problems in dynamic programming, network flows,etc.	1	3	2	2	0	0	0	0	0	0	0	3
		CO3	Design and develop real time application using graph theory	1	0	2	0	2	3	0	0	0	0	2	0
		CO4	Construct and communicate proofs of theorems	0	2	0	0	0	0	0	1	0	3	2	0
CSPE02	Software Engineering	CO1	Assess each module given the overall Software engineering practice and enhance the software project management skills	0	2	0	0	2	0	0	3	3	2	3	0
		CO2	Comprehend the systematic methodologies involved in SE	0	1	0	0	2	0	0	2	2	1	2	0

		CO3	Design and develop a software product in accordance with SE principles	2	0	2	0	3	1	0	1	0	1	1	0
		CO4	Design risk mitigation plans for software products	0	0	0	2	2	1	0	0	3	3	3	0
CSPE03	Design Thinking	CO1	Convert real-life problems into methodical problems	2	0	1	0	2	0	0	0	2	0	0	0
		CO2	Apply various visualization principles for problem and solution representation	0	0	0	0	2	3	0	2	0	1	2	0
		CO3	Design solutions by applying an integrated approach to design thinking	3	0	1	0	2	0	0	0	2	0	0	2
		CO4	Understanding customer feedback	0	0	0	0	0	0	0	0	0	3	0	0
CSPE04	Advanced Data Structures and Algorithms	CO1	Apply the appropriate data structure for solving real-world problems	1	1	1	1	2	2	0	0	0	0	2	0
		CO2	Decide on appropriate string matching algorithms for solving practical problems	1	1	1	2	2	3	0	0	3	0	3	0
		CO3	Appreciate the backtracking and branch and bound technique to solving NP problems	0	2	1	0	2	0	0	3	0	0	3	0
		CO4	Analyse geometric problems and NP-complete problems and demonstrate the impact of reducibility on the real time problems.	1	1	2	0	0	3	3	0	0	0	0	0

CSPE05	Multimedia Systems	CO1	Design multimedia components and develop integrated, collaborative multimedia systems	2	1	3	0	0	3	0	2	0	0	2	0
		CO2	Understand various compression standards and techniques in multimedia	3	2	3	0	0	3	1	0	2	0	0	1
		CO3	Understand protocols for multimedia	0	3	0	0	0	2	0	0	0	0	0	0
		CO4	Develop security algorithms for the specialized applications	2	0	3	0	0	0	2	0	2	0	2	2
CSPE06	Computing Algorithms based on Indian Knowledge Systems	CO1	Ability to understand the necessity and importance of mathematical concepts of Indian origin.	3	2	1	0	3	2	3	1	3	0	1	3
		CO2	Ability to develop and apply mathematical formulas based on Indian Mathematics text.	3	2	1	1	3	0	0	0	0	2	1	3
		CO3	Ability to relate the mathematical formulae of Indian origin in a real-life situation.	3	0	0	3	3	3	0	2	0	0	1	3
		CO4	Ability to compare the performances of conventional computing algorithms with algorithms based on Indian mathematical concepts.	1	3	3	3	3	2	3	2	0	0	0	3
CSPE11	Real Time Systems	CO1	Analyze scheduling problems	3	0	1	0	2	2	0	0	2	0	2	0
		CO2	Develop real-time systems	3	2	1	0	2	0	0	0	3	0	2	0

		CO3	Understand basic multi-task scheduling algorithms	2	3	0	0	0	0	0	2	0	0	2	0
		CO4	Understanding tools and utilizing them for real-time environment	0	2	0	0	0	0	0	0	2	0	1	0
CSPE12	Cloud Computing	CO1	Articulate the concepts, technologies, and applications of cloud computing	3	1	3	0	0	3	0	0	0	3	2	3
		CO2	Identify cloud computing architecture and infrastructure, and apply appropriate computing mechanisms for cloud environments.	3	1	3	0	3	0	0	2	2	3	3	0
		CO3	Provide the appropriate cloud computing solutions and recommendations according to the applications	3	0	3	0	0	0	2	1	0	3	2	1
		CO4	Gain knowledge on recent advances and implementation of programming modes in cloud computing	0	0	3	3	2	2	3	0	0	1	1	2
CSPE13	Design and Analysis of Parallel Algorithms	CO1	Develop parallel algorithms for standard problems and applications	3	0	3	0	0	2	0	0	0	0	0	0
		CO2	Explain and derive the complexity of algorithms for basic and collective communication operations	3	2	2	0	3	0	0	0	2	0	2	0

		CO3	Apply different methods and performance measures to analyze algorithms with respect to cost and scalability	3	3	0	3	0	3	0	0	2	0	2	0
		CO4	Perform design and analysis of parallel algorithms in real time applications	2	0	3	0	0	2	0	0	0	0	0	2
CSPE14	Parallel Architectures and Programming	CO1	comprehend parallel architecture and its importance in solving engineering problems	3	0	0	0	3	2	0	0	0	0	3	0
		CO2	Summarize and differentiate different parallel programming strategies	0	3	0	0	0	0	0	0	0	0	3	0
		CO3	Design parallel programs in parallel hardware environment	3	0	3	0	2	3	2	0	3	0	3	0
		CO4	Design and write programs that can make efficient use of multiple cores, GPU Processing power	0	3	3	0	0	3	0	0	0	0	0	3
CSPE15	GPU Computing	CO1	Understand the basics of GPU architecture & programs using CUDA and OpenCL	3	0	0	0	0	0	0	0	0	0	3	0
		CO2	Develop parallel applications targeting GPUs	0	0	3	0	3	3	0	0	3	0	0	2
		CO3	Develop Debugging tool	0	0	3	0	2	2	0	0	3	0	3	0

		CO4	Analyse the performance of the memory and thread execution in view of parallel programming	3	3	0	0	0	3	0	2	0	3	0	3
CSPE16	Internet of Things - Principles and Practices	CO1	Explain the concept of IoT & analyze various protocols for IoT	3	0	2	0	0	1	0	0	0	1	1	0
		CO2	Design a PoC of an IoT system using Rasperry Pi/Arduino	2	3	0	0	0	0	0	0	0	1	2	0
		CO3	Apply data analytics and use cloud offerings related to IoT	1	0	3	0	3	0	0	0	2	0	0	0
		CO4	Analyze applications of IoT in real-time scenario	3	0	1	0	0	1	0	0	0	0	0	2
CSPE17	Quantum Computing	CO1	Understand the basic principles of quantum computation and quantum mechanics.	3	3	0	0	0	0	0	0	0	0	0	0
		CO2	Understand the difference between classical and quantum algorithm approach and Design quantum circuits using quantum gates.	3	3	3	0	2	0	0	0	0	0	0	0
		CO3	Analyse the behaviour of basic quantum algorithms.	3	3	3	0	3	0	0	0	0	0	2	0
		CO4	Learn about the operators involved in Quantum computing and their applications	3	0	0	0	3	0	0	0	0	0	0	2

CSPE21	Cyber Physical Systems	CO1	To gain knowledge on the computer architectural design principles and performance enhancement strategies and distributed systems.	2	0	3	1	1	0	1	0	0	0	0	0
		CO2	To Solve the performance related problems of real time operating system.	1	0	2	1	0	0	0	0	1	0	0	0
		CO3	To analyze the performance of embedded processing, memory, bus efficiencies, real time Operating System performance Hardware, Software codesign.	0	1	0	3	3	2	2	1	1	2	1	1
		CO4	To understand and develop Secure and Safe AI enabled CPS for real world applications in Industry 5.0	0	1	0	0	0	0	2	3	0	0	0	0
CSPE22	Internetworking Protocols	CO1	Gain insight about basic network theory and layered communication architectures.	3	0	1	0	0	0	2	0	0	0	3	0
		CO2	Able to resolve the medium access and routing problems under various scenarios.	1	2	0	0	0	0	2	0	0	0	3	0
		CO3	Implement TCP and UDP protocols with better QoS support for the real time applications.	1	2	2	0	0	2	2	0	0	0	3	0

		CO4	Propose algorithms at the appropriate layer for any communication network task.	0	1	1	0	2	0	0	0	0	3	0	0
CSPE23	Network Security	CO1	Determine appropriate mechanisms for protecting the network	2	2	1	0	3	1	0	0	0	0	0	0
		CO2	Understand the security protocols and challenges	0	0	0	0	0	0	0	0	0	0	0	0
		CO3	Design and develop security solutions for a given application or system	1	0	2	0	2	3	0	2	0	2	1	2
		CO4	Apply Authentication algorithms for Security	3	1	3	0	2	2	0	0	3	0	0	2
CSPE24	Wireless Network Systems	CO1	Make a critical assessment of wireless networks, including cellular systems, MAC techniques, and frequency management	2	0	0	0	0	2	0	0	0	0	2	0
		CO2	Comprehend the fundamentals of Wireless WAN and their evolution, including GSM, CDMA, and third-generation systems.	0	3	0	0	0	1	0	0	0	0	0	2
		CO3	Analyze the architecture, services, and standards of Wireless LANs, including IEEE 802.11, HIPERLAN, and WiMAX	0	0	2	2	0	3	0	0	3	0	0	0
		CO4	Apply the knowledge gained in the development of MAC and network layer	0	2	0	0	0	2	0	0	0	0	0	0

			protocols for AdHoc networks and Wireless MAN/PAN.												
CSPE25	Advanced Cryptography	CO1	Understand the concepts of Blockchain Technology, Zero knowledge Proof and Multi party Computation	3	3	3	0	0	3	3	0	0	0	0	0
		CO2	Break cryptosystems that are not provably secure	3	0	1	0	0	1	3	0	0	0	0	0
		CO3	Derive simple provable security proofs for cryptographic schemes	3	0	1	0	0	1	0	0	0	0	0	0
		CO4	Design and implement cryptographic protocols and use cryptographic algorithms in security	3	0	3	0	0	3	0	3	0	0	0	0
CSPE26	Information Security	CO1	Illustrate the legal, ethical and professional issues in information security	0	3	0	0	0	0	0	3	0	0	2	0
		CO2	Demonstrate the aspects of risk management	0	0	0	0	3	0	0	3	3	2	2	0
		CO3	Become aware of various standards in the Information Security System	0	3	0	0	0	0	0	1	0	0	1	0
		CO4	Design & implementation of Security Techniques	3	0	3	0	0	3	0	0	0	0	3	2
CSPE27	Metaverse and Blockchain	CO1	Understand the History of Metaverse and the role of Metaverse to connect the real world and blockchain.	2	2	3	0	0	0	1	0	0	0	0	0
		CO2	Working with advanced development of blockchain in the future.	2	2	3	0	0	0	0	0	0	0	0	0

		CO3	Exploring the open ecosystem of smart properties and assets.	2	2	3	0	0	0	0	0	0	0	0	0	0
		CO4	Integrating futuristic technologies such as blockchain,cryptocurrency, DAO, AR/VR	2	0	3	0	0	0	2	0	0	0	1	0	
CSPE31	Image Processing and Applications	CO1	Differentiate and interpret various image enhancement techniques	2	3	3	2	0	2	0	0	0	0	2	0	
		CO2	Reconstruct the image from the degraded image	3	0	2	0	1	0	0	0	0	0	0	2	
		CO3	Analyze and use appropriate image compression techniques	2	3	2	0	1	2	0	0	0	0	2	0	
		CO4	Suggest proper image features for classification problems	3	3	0	0	0	3	0	0	0	0	2	0	
CSPE32	Machine Learning Techniques and Practices	CO1	Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning	3	0	0	0	0	0	0	0	0	0	0	0	
		CO2	Appreciate machine learning challenges and suggest solutions for the same	0	3	0	0	0	1	0	0	0	0	0	0	
		CO3	Design and implement various machine learning algorithms in a range of real-world applications	0	0	3	1	0	2	0	0	0	0	0	0	

		CO4	Suggest supervised / unsupervised machine learning approaches for any application	0	0	3	3	0	1	0	0	0	0	0	0
CSPE33	Deep Learning Techniques	CO1	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domain	0	2	3	0	0	3	0	0	0	0	3	0
		CO2	Incorporate transfer of knowledge in machine learning algorithms	2	3	3	0	0	0	0	0	1	0	1	0
		CO3	Implement deep learning algorithms and solve real-world problems	3	0	3	0	0	3	0	0	0	0	0	3
		CO4	Develop Deep Learning techniques using Python	3	0	0	3	0	3	0	0	0	1	2	0
CSPE34	Natural Language Processing	CO1	Sugges appropriate lexical and parsing techniques for a given natural language	0	2	0	0	3	0	0	0	3	3	0	0
		CO2	Apply appropriate statistical models for a given natural language application	3	0	2	0	0	3	0	0	0	0	0	3
		CO3	Modify existing algorithms to suit any natural language for processing	0	3	3	0	2	0	0	0	3	0	2	0
		CO4	Suggest appropriate pre-processing steps essential for the various applications involving natural language processing	0	1	1	0	1	1	0	0	1	0	0	1

CSPE35	Deep Learning Paradigms for Computer Vision	CO1	Implement fundamental image processing techniques required for computer vision	2	3	0	0	3	0	0	0	0	0	0	0
		CO2	Employ the motion analysis techniques for solving real life problem	3	3	0	0	1	0	0	0	0	1	0	0
		CO3	Apply the deep learning architectures to various problems	2	2	0	0	1	0	0	0	0	0	0	0
		CO4	Develop applications of computer vision using deep learning techniques	0	3	0	0	2	0	1	0	0	0	0	0
CSPE36	Responsible & Ethical AI	CO1	Design AI applications incorporating ethical aspects of AI	3	3	3	3	2	3	2	3	1	1	2	2
		CO2	Suggest appropriate levels of transparency and security requirement for AI applications	3	3	3	2	2	2	1	2	1	0	1	1
		CO3	Modify existing metrics as well as define new metrics for measuring the responsibility level of applications involving AI	3	3	3	2	2	2	2	1	1	1	1	1
		CO4	Design AI applications incorporating privacy and security aspects	2	2	3	2	1	2	1	3	1	1	2	1
CSPE37	Generative AI	CO1	To design and develop fundamental Deep Learning and Generative AI based models	3	2	1	0	0	1	1	1	1	0	1	0

		CO2	To gain knowledge in developing prompts for generating Images, Videos and Codes in various domains	0	2	3	2	0	2	0	1	0	2	1	1
		CO3	To apply the Generative AI models to develop real world applications	3	1	2	2	2	0	0	1	0	1	1	0
		CO4	To design and develop Safe and Responsible AI systems	0	1	1	2	2	2	3	3	0	1	0	0
CSPE38	Cognitive Science	CO1	Map the concepts of Psychology, Nervous system and brain and sensory motor information attributes to real world problems involving AI	3	3	3	2	1	3	2	2	3	1	0	0
		CO2	Analyze the Roots of Cognitive Science	2	2	2	2	1	2	2	2	3	1	0	0
		CO3	Exploit Language and Embodiment features	2	2	2	2	1	2	2	2	3	1	0	0
		CO4	Explore the Affordances in biological and artificial systems, Cognitive Development and make Attention, Learning, Memory, Reasoning, Social Cognition aspects to solve real world problems.	3	2	3	2	2	3	2	2	3	1	0	0
CSPE39	Drone Technologies	CO1	Comprehend Hardware components and software programming requirements of drones.	2	2	3	3	2	3	3	1	0	0	1	1

		CO2	Know about a various type of drone technology	1	3	3	2	1	3	2	1	1	0	1	1
		CO3	Select appropriate sensors and actuators for Drones	2	3	2	1	1	2	3	0	2	0	1	1
		CO4	Use navigation and communication systems in UAVs.	3	3	3	2	1	2	2	1	1	0	1	1
CSPE41	Augmented and Virtual Reality	CO1	Provide an opportunity to explore the research issues in Augmented Reality and Virtual Reality (AR & VR).	0	2	3	0	0	3	0	1	0	1	2	2
		CO2	Understand fundamentals of computer graphics	2	0	3	0	0	0	0	0	0	0	0	0
		CO3	Know the basic concept and framework of virtual reality and computer-human interaction	3	0	1	0	2	2	0	0	0	1	3	0
		CO4	Develop simulator for real time application using AR & VR	3	2	3	2	0	3	2	0	0	0	0	2
CSPE42	Game Theory	CO1	Identify strategic situations and represent them as games	3	0	2	0	3	0	0	0	3	0	0	0
		CO2	Solve simple games using various techniques	2	1	0	1	0	2	0	0	0	0	2	0
		CO3	Recommend and prescribe which strategies to implement	0	1	0	0	0	0	0	1	0	0	2	0
		CO4	Develop Static and Dynamic Games	1	0	1	0	2	2	0	0	2	2	2	0

CSPE43	Software Testing and Automation	CO1	Design test cases suitable for a software development for different domains	0	0	2	2	0	0	0	1	0	0	1	0
		CO2	Prepare test planning based on the document	3	0	0	0	2	0	0	1	0	0	1	0
		CO3	Document test plans and test cases designed	0	0	0	0	3	1	0	3	0	0	3	0
		CO4	Use automatic testing tools	2	0	0	0	0	0	0	1	0	0	2	0
CSPE44	Agile Software Development	CO1	Distinguish between agile software development and traditional software development	0	2	0	0	0	0	0	2	0	3	3	0
		CO2	Design and provide the necessary measurements and metrics for agile software development problems	0	0	2	0	0	2	0	0	0	2	3	0
		CO3	Integrate best practices of traditional &agile software development and use in real-time problem solving	0	0	0	0	3	0	0	1	3	3	3	0
		CO4	Estimate risk of scrum projects	2	0	2	0	0	0	0	2	0	0	1	0
CSPE45	Web Technology and its Applications	CO1	Understand and interpret standard web technologies	0	1	0	2	0	0	0	2	0	0	2	0
		CO2	Build real world applications using client side and server side scripting languages	3	0	3	0	0	2	0	0	0	3	3	0
		CO3	Design and develop applications using web technologies	0	0	3	0	3	3	0	0	0	3	3	0
		CO4	Handling web application data with databases	3	0	0	1	0	0	0	2	0	0	0	0

CSPE46	Brain Computer Interface and its Applications	CO1	Comprehend and appreciate the significance and role of BCI in the present contemporary world.	0	3	0	0	2	2	0	0	1	0	0	2
		CO2	Assign functions appropriately to the human and to the machine.	2	2	2	3	2	3	3	1	1	0	0	1
		CO3	Select appropriate feature extraction and analysis methods	1	1	2	3	1	1	2	0	0	0	0	0
		CO4	Use machine learning algorithms for translation.	1	3	1	1	0	2	3	0	0	0	0	0
CSPE47	Full stack development	CO1	Understand the various stacks available for web application development	3	3	3	0	2	0	0	0	0	0	1	0
		CO2	Use Node.js, features of Angular and Express for application development	3	3	3	0	2	0	0	0	0	0	1	0
		CO3	Develop applications with MongoDB	3	3	3	0	2	0	0	0	0	0	1	0
		CO4	Develop React applications	3	3	3	0	2	0	0	0	0	0	1	0
CSPE48	DevOps	CO1	Understand different actions performed through Version control tools like Git.	3	3	2	2	1	3	2	0	1	0	2	1
		CO2	Understand to leverage Cloud-based DevOps tools using Azure DevOps	2	3	3	3	2	3	1	1	1	0	2	1
		CO3	Perform Continuous Integration and Continuous Testing and Continuous Deployment using Jenkins	2	2	3	3	1	3	1	0	1	0	2	1

			by building & automating test cases using Maven & Gradle												
		CO4	Ability to do configuration management using Ansible	3	2	2	3	1	3	1	0	1	0	2	1
CSPE51	Data Interpretation and Analysis	CO1	Comprehend the essential concepts in probability theory	3	2	2	3	0	1	0	0	0	0	1	1
		CO2	Use mathematical tools for analyzing probabilities	1	3	2	2	0	2	0	0	0	0	1	1
		CO3	Applying the appropriate concepts of probability and statistics to solve real-world problems	1	1	1	1	0	0	0	0	0	0	0	0
		CO4	Understand various distributions, hypothesis tesing, regression models and their applications	2	2	3	1	0	1	0	0	0	0	1	1
CSPE52	Advanced Database Management Systems	CO1	Comprehend the complex query processing techniques	1	0	0	0	0	0	0	0	0	1	2	0
		CO2	Design distributed and object oriented databases	2	2	1	0	1	2	0	0	1	2	2	2
		CO3 and	Design and implement multimedia databases and writing query structure	0	3	2	0	3	0	0	0	2	2	2	0
		CO4	Develop skill set in file organization, Query Optimization, Transaction management & database administration techniques	2	0	2	0	0	0	0	2	2	2	2	0

CSPE53	Data Analytics	CO1	Evaluate the use of data from acquisition through cleaning, warehousing, analytics, and visualization to the ultimate business decision	1	0	1	3	0	0	0	2	0	0	2	0
		CO2	Mine data and carry out predictive modelling and analytics to support business decision-making	3	2	3	0	0	3	0	1	0	0	3	0
		CO3	Suggest prescriptive modelling techniques and execute real-time analytical methods on streaming datasets to react quickly to customer needs	3	2	3	0	1	2	0	0	1	0	2	1
		CO4	Apply graph analytics on data	3	2	3	0	0	3	0	1	3	0	3	0
CSPE54	Data Science	CO1	Understand the data science concepts, techniques and models	0	3	0	0	2	0	0	0	1	0	0	0
		CO2	Forecast the time series data	1	0	0	0	0	0	0	0	0	0	1	0
		CO3	Learn and apply different mining algorithms and recommendation systems for large volumes of data	2	0	0	0	0	0	0	0	1	0	0	0
		CO4	Perform analytics on data streams	2	0	3	0	0	3	0	0	0	0	0	2
CSPE55	Social Network Analysis	CO1	Develop semantic web related applications	0	0	3	0	0	2	0	0	0	0	0	0
		CO2	Describe and represent knowledge using ontology	2	0	0	0	2	0	0	0	2	0	0	0

		CO3	Inspect and predict human behavior in social web and related communities	1	0	0	0	0	1	0	3	0	0	2	0
		CO4	Organize and visualize social networks	2	0	1	0	2	2	0	0	0	0	2	3
CSPE56	Human Computer Interaction	CO1	Design and Develop processes and life cycle of Human Computer Interaction	1	0	0	0	1	2	0	2	1	0	1	0
		CO2	Analyse product usability evaluations and testing methods	2	0	0	0	0	0	0	3	0	0	2	0
		CO3	Apply the interface design standards/guidelines for cross cultural and disabled users	0	0	2	0	2	3	0	2	2	0	2	0
		CO4	Categorize, Design and Develop Human Computer Interaction in proper architectural structures	1	3	2	0	0	1	0	0	0	0	2	2
CSPE57	Text, Speech and Video Analytics	CO1	Understand classification algorithms for text documents	3	3	3	3	2	2	3	0	1	1	1	2
		CO2	Understand the speech recognition system	2	3	3	3	1	2	3	0	1	1	1	2
		CO3	Know image and video analytic fundamentals	3	1	3	1	0	1	2	0	1	0	1	2
		CO4	Understand the real time use of text, speech, image and video analytics	3	3	3	3	1	2	3	0	1	1	1	2

3 - High; 2 - Medium; 1 – Low

OPEN ELECTIVES (OE)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSOE11	Big Data Analytics	CO1	Understand the characteristics of big data and concepts of Hadoop ecosystem	3	0	1	0	0	3	0	0	0	0	3	0
		CO2	Understand the concepts of Scala programming	0	1	0	1	0	0	0	0	1	0	1	0
		CO3	Apply Mapreduce programming model to process big data	3	0	2	0	1	2	0	0	3	0	0	1
		CO4	Analyze Spark and its uses for big data processing	3	1	0	0	2	0	0	0	3	0	0	0
CSOE12	Cloud & Grid Computing	CO1	Understand the core concepts of Distributed computing	2	3	1	0	0	0	2	0	0	0	0	0
		CO2	Articulate the Virtualization concepts	2	0	2	0	0	3	0	0	0	0	0	0
		CO3	Identify the architecture, service models and deployment models of Cloud	0	3	1	0	0	2	0	0	0	0	2	0
		CO4	Understand and build secure and reliable Grid and Cloud applications	0	2	0	0	0	2	3	0	0	0	3	2
CSOE13	Computer Graphics and Multimedia Systems	CO1	Understand the various computer graphics hardware and display technologies	0	0	1	0	0	1	2	0	0	0	0	0

		CO2	Implement various 2D and 3D objects transformation	3	0	2	1	0	1	0	0	2	0	2	0
		CO3	Apply 2D and 3D viewing technologies into the real world applications	3	0	2	2	0	2	0	0	2	0	2	2
		CO4	Understand Hypermedia and distributed multimedia systems	3	0	3	3	0	2	0	0	0	0	0	0
CSOE14	Distributed Architecture	CO1	Understand the distributed system architecture	3	0	3	2	0	3	0	0	0	0	3	0
		CO2	Implement CORBA and MICO	3	2	2	0	0	3	0	0	3	0	0	0
		CO3	Design Middleware Platforms	3	3	3	0	2	0	0	0	2	0	0	3
		CO4	Analyse the performance of the distributed systems by running various applications	3	2	3	0	0	2	0	0	0	3	3	3
CSOE15	Human Computer Interaction	CO1	Design and Develop processes and life cycle of Human Computer Interaction	1	0	0	0	1	2	0	2	1	0	1	0
		CO2	Analyze Product Usability evaluations and testing methods	2	0	0	0	0	0	0	3	0	0	2	0
		CO3	Apply the interface design standards/guidelines for cross cultural and disabled users	0	0	2	0	2	3	0	2	2	0	2	0
		CO4	Categorize, Design and Develop Human Computer Interaction in proper architectural structures	1	3	2	0	0	1	0	0	0	0	2	2

CSOE16	Image Processing	CO1	Process image enhancement and restoration techniques	2	0	3	2	0	2	0	0	0	0	0	0
		CO2	Apply image compression and segmentation Techniques	2	3	2	0	2	2	0	0	0	0	0	0
		CO3	Apply transforms for processing of images	3	2	3	0	2	2	0	0	0	0	2	1
		CO4	Design and develop image processing applications	1	0	1	0	2	3	0	1	1	1	2	2
CSOE17	Internet of Things	CO1	Explain the concept of IoT & analyze various protocols for IoT	3	3	2	0	0	1	0	0	0	1	1	0
		CO2	Design a PoC of an IoT system using Rasperry Pi/Arduino	1	0	3	0	3	0	0	0	2	0	0	0
		CO3	Apply data analytics and use cloud offerings related to IoT	3	0	1	0	0	1	0	0	0	0	0	2
		CO4	Analyze applications of IoT in real-time scenario	0	0	3	0	0	1	0	0	0	0	2	0
CSOE18	Machine Learning for Engineering Applications	CO1	Solve typical machine learning problems	3	0	2	0	1	0	0	0	1	0	1	0
		CO2	Design and implement various machine learning algorithms for real-world applications	2	0	0	3	0	0	0	0	0	0	3	0
		CO3	Suggest supervised /unsupervised machine learning approaches for any application	0	0	3	0	0	3	0	0	0	0	2	3
		CO4	Handle tools of machine learning	0	3	3	0	0	2	0	0	0	1	2	0

CSOE19	Security Principles	CO1	Understand the basics of information security and various standards in the Information Security System	3	0	1	0	0	1	0	2	1	0	2	0
		CO2	Illustrate the legal, ethical and professional issues in information security	3	3	0	0	0	0	0	1	0	1	1	0
		CO3	Demonstrate the aspects of risk management	0	0	0	0	0	0	0	3	0	2	2	0
		CO4	Design and implementation of Security Techniques.	1	0	2	0	2	3	0	0	0	0	3	2
CSOE20	Soft Computing	CO1	Comprehend machine learning and soft computing techniques in solving real world applications	0	0	3	0	0	1	0	0	0	0	2	0
		CO2	Design and develop ML techniques with assistance of MATLAB	2	0	2	2	0	2	0	0	0	0	1	0
		CO3	Visualize and analyze behavioural pattern to develop evolutionary algorithm	0	3	0	2	0	0	0	1	0	0	2	0
		CO4	Design Algorithm for classification Problems	2	3	3	0	0	3	0	0	0	0	0	2
CSOE21	Software Project Management	CO1	Design and develop project modules and assign resources	0	0	0	0	3	0	0	2	3	3	2	0
		CO2	Comprehend and analyse estimation, scheduling and risk management metrics	2	0	2	0	1	2	0	2	2	2	2	0
		CO3	Analyse Quality Management tools and charts	0	0	3	0	2	2	0	0	0	0	2	0

		CO4	Analyse Mathematical Proof for above on real time case studies	0	0	3	2	0	3	0	2	0	0	2	0
CSOE22	Software Testing & Practices	CO1	Design test cases suitable for a software development for different domains	0	1	1	2	3	0	1	0	3	0	1	1
		CO2	Prepare test planning based on the document	0	0	0	2	1	0	0	3	2	2	0	2
		CO3	Document test plans and test cases designed	2	3	0	0	0	2	0	0	1	0	0	0
		CO4	Use the automated testing tools to check the behaviour of the real time application	0	2	3	3	0	1	0	0	0	0	1	1
CSOE23	Web Technology	CO1	Build real world applications using client side and server side scripting languages	2	2	1	1	0	2	0	0	3	0	0	0
		CO2	Design and develop an e-governance application using web technology	3	3	3	0	1	3	0	0	3	3	2	0
		CO3	Design Database connectivity with JSP	0	0	1	1	0	1	0	0	0	0	2	0
		CO4	Design case study for student Information System and Health Management system	3	3	3	0	0	3	0	0	0	0	2	2

3 - High; 2 - Medium; 1 – Low

MINORS (MI)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSMI11	Data Structures and Algorithms	CO1	Understand and Analyze Algorithms and Data Structures	1	1	1	2	2	3	0	0	0	0	0	0
		CO2	Develop and Apply Tree and Graph Algorithms	0	1	2	0	0	2	0	0	3	0	3	0
		CO3	Utilize Advanced Algorithmic Paradigms	0	2	1	0	2	0	0	3	0	0	3	0
		CO4	Master Searching and Sorting Techniques	1	0	2	0	0	3	0	0	0	0	0	0
CSMI12	Computer Organization	CO1	Understand the architecture and functionality of the central processing unit	2	3	2	0	0	0	2	0	0	0	0	0
		CO2	Analyze the hardware and software issues and the interfacing	0	0	3	0	2	0	0	0	0	0	0	0
		CO3	Work out the tradeoffs involved in designing a modern computer system	3	3	0	0	1	0	2	0	0	2	0	3
		CO4	Understand the various memory systems and I/O communication	0	0	0	0	3	0	1	0	0	0	0	0
CSMI13	Operating Systems	CO1	Comprehend the techniques used to implement the process manager	2	0	2	2	0	0	0	0	0	0	0	0
		CO2	Comprehend virtual memory abstractions in OS	2	2	0	0	0	0	0	0	0	0	0	0

		CO3	Design and develop file system interfaces	2	0	3	3	2	3	0	1	2	0	2	1
		CO4	Design protection mechanisms for securing the system	2	2	2	2	2	3	0	1	2	0	2	1
CSMI14	Database Management Systems	CO1	Install, configure, and interact with a relational database management system	0	0	3	0	0	2	0	0	0	0	0	0
		CO2	Master the basics of SQL and construct queries using SQL	1	0	3	0	0	2	0	0	2	0	2	0
		CO3	Design and develop a large database with optimal query processing	2	0	3	0	3	0	0	0	3	0	1	0
		CO4	Develop efficient storage scheme of saving and retrieving Records and Files and design the database with normalization techniques	1	0	3	0	0	2	0	0	0	0	0	2
CSMI15	Software Engineering	CO1	Enhance the software project management skills	1	0	0	0	2	0	0	3	1	2	1	0
		CO2	Comprehend the systematic methodologies involved in SE	2	0	0	0	2	0	0	0	3	0	0	0
		CO3	Design and develop a software product in accordance with SE principles	3	0	3	0	0	2	0	0	0	0	3	0
		CO4	Organize all the testing tools and its usage	2	3	1	0	0	1	0	0	0	0	2	0

CSMI16	Computer Networks	CO1	Gain insight about basic network theory and layered communication architectures	1	2	0	0	0	0	0	0	0	0	0	0
		CO2	Identify the components required to build different types of networks	1	0	0	0	2	1	0	0	3	0	0	0
		CO3	Choose the required functionality at each layer for given application	2	0	0	0	2	1	0	0	3	0	3	0
		CO4	Trace the flow of information from one node to another node in the network	0	2	0	0	1	1	0	0	3	0	3	0
CSMI17	Artificial Intelligence	CO1	Ability to design a plan for the real world problems and mapping it to the digital world	2	2	3	3	2	3	0	0	0	0	3	0
		CO2	Suggest appropriate search strategies for any AI problem	3	3	0	1	0	0	0	0	0	0	0	0
		CO3	Appreciate the uncertainty in designing AI systems and propose algorithms for the same	3	3	0	1	0	0	0	0	0	0	0	0
		CO4	Ability to identify problems that are amenably solved by AI methods	0	2	0	3	0	3	0	0	2	0	3	2
CSMI18	Internetworking Principles	CO1	Gain insight about basic network theory and layered communication architectures.	3	0	1	0	0	0	2	0	0	0	3	0

		CO2	Able to resolve the medium access and routing problems under various scenarios.	1	2	0	0	0	0	2	0	0	0	3	0
		CO3	Implement TCP and UDP protocols with better QoS support for the real time applications.	1	2	2	0	0	2	2	0	0	0	3	0
		CO4	Propose algorithms at the appropriate layer for any communication network task.	0	1	1	0	2	0	0	0	0	3	0	0
CSMI19	Web Application Development	CO1	To understand the various components of web development and develop simple web applications	3	3	3	0	2	0	0	0	0	0	1	0
		CO2	To learn Node.js features and applications	3	3	3	0	2	0	0	0	0	0	1	0
		CO3	To develop applications with MongoDB	3	3	3	0	2	0	0	0	0	0	1	0
		CO4	To understand the role of Angular and Express in web applications	3	3	3	0	2	0	0	0	0	0	1	0

3 - High; 2 - Medium; 1 – Low

ESSENTIAL LABORATORY REQUIREMENT (ELR)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSLR31	Data structures Laboratory	CO1	Analyze and compare various linear and non-linear data structures	2	3	3	0	3	0	0	2	0	0	3	0
		CO2	Code, debug & demonstrate the working nature of different types of data structures & their applications	3	0	1	0	3	2	0	0	3	2	0	0
		CO3	Implement, analyse, and evaluate the searching and sorting algorithms	2	0	2	3	0	3	0	0	0	0	2	0
		CO4	Choose the appropriate data structure for solving real world problems	3	0	1	2	0	3	0	0	0	0	3	0
CSLR32	Digital Laboratory	CO1	Design and develop basic digital systems	1	0	1	0	2	2	2	0	1	0	0	0
		CO2	Design synchronous sequential circuits using basic flip-flops, counters, PLA, PAL	2	0	2	0	3	3	3	0	1	0	0	0
		CO3	Debug digital circuits	3	3	3	1	0	2	3	0	1	0	0	0
		CO4	Use boolean simplification techniques to design a combinational hardware circuit	0	1	0	0	0	1	2	0	0	0	0	0
CSLR41	Algorithms Laboratory	CO1	Solve and analyze general algorithms based on space and time complexity	3	2	0	0	2	0	0	2	0	0	0	2

		CO2	Implement and empirically compare fundamental algorithms & data structures to real-world problems	3	2	1	0	2	2	0	0	2	0	2	0
		CO3	Design, develop, and optimize algorithms in different paradigms	3	0	1	0	2	2	0	0	0	0	0	2
		CO4	Implement advanced data structures	3	1	0	0	2	0	0	0	0	0	0	0
CSLR42	Operating Systems Lab	CO1	Write program on shell script and Pthread	3	0	1	0	2	0	0	0	0	0	0	0
		CO2	Solve synchronization problems	3	0	0	0	2	0	0	0	2	0	2	0
		CO3	Compare & contrast various CPU scheduling algorithms, Memory allocation policy	3	2	1	0	0	0	0	0	0	0	0	0
		CO4	Differentiate the disk scheduling algorithms	3	2	0	0	0	0	0	0	0	0	0	0
CSLR51	Database Management Systems Laboratory	CO1	Identify Structure Query Language statements used in creation and manipulation of Database and comprehend the internal working of a database system	2	2	1	0	1	2	1	0	0	0	2	0
		CO2	Use databases for building client server applications	3	0	1	0	1	2	0	0	0	2	0	1
		CO3	Design and develop a database using SQL and the mechanism in connecting with a Web based GUI	3	0	1	0	1	2	1	2	0	2	0	1
		CO4	Analyze and design a real database application	3	2	1	2	0	2	0	2	0	2	0	1
CSLR52	Networks Laboratory	CO1	Implement client-server applications using Sockets	1	0	0	1	1	2	2	0	0	0	0	0

		CO2	Invoke analytical studies of Computer Networks through network simulation	1	0	1	2	0	0	2	0	0	0	3	0
		CO3	Design a network using NS3 toolkit and its importance in designing a real network	0	1	2	0	3	3	0	0	2	0	0	3
		CO4	Measure and analyze the network parameters for a high throughput network.	0	1	1	0	0	2	0	3	0	3	0	0
CSLR61	Embedded Systems Laboratory	CO1	Assemble and troubleshoot hardware devices	3	1	2	3	1	0	0	0	0	0	0	1
		CO2	Write programs for interfacing keyboard, display, motor, and sensor	3	3	3	3	1	1	0	0	0	1	0	0
		CO3	Design and program an embedded system at the basic level	3	0	1	1	1	0	0	0	0	1	0	0
		CO4	Write programs in ARM for a specific Application	3	3	3	2	1	1	0	0	0	0	0	0
CSLR62	App Development Laboratory	CO1	Construct Web pages using HTML/XML & style sheets	2	2	3	2	3	3	2	3	2	3	3	0
		CO2	Build dynamic web pages with validation using Java Script objects & by applying different event handling mechanisms	3	2	3	3	3	3	0	3	0	3	3	2
		CO3	Develop Web application which makes use of PHP and AJAX programming	3	3	3	2	3	3	0	3	0	3	0	2
		CO4	Deploy applications to hand-held devices	3	2	3	2	2	3	0	3	2	3	2	2

3 - High; 2 - Medium; 1 - Low

HONORS (HO)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSHO11	Software Defined Networking	CO1	Comprehend Software Defined Networks	0	3	0	2	0	1	0	0	0	0	1	0
		CO2	Design and implement software defined network	0	2	1	0	0	1	0	0	0	0	0	0
		CO3	Design algorithm for virtualization	2	0	2	0	2	3	0	0	3	0	3	0
		CO4	Design algorithm for big data analytics	1	1	2	0	2	3	0	0	2	0	0	3
CSOH12	Multi-Core Programming	CO1	To understand the limitations of ILP and the necessity of multi-core architecture	3	0	0	3	3	0	0	0	0	0	0	1
		CO2	To be able to know the basic concepts of multi core programming to manage threads using the role of Open-MP	3	2	0	2	0	0	0	3	3	0	0	1
		CO3	To be able to understand various programming constructs and Solve the issues related to multiprocessing and suggest solutions in multicore architecture and multithreaded application	3	0	0	3	3	0	0	3	0	0	0	3
		CO4	To design scalable and high-performance software systems, which	3	2	0	3	3	2	0	3	0	0	0	3

			includes performance analysis, algorithmic techniques for high performance, instruction-level optimizations, caching optimizations, parallel programming, & building scalable systems												
CSHO13	Pervasive and Ubiquitous Computing	CO1	Understand the fundamental theoretical concepts in pervasive computing	2	3	1	0	0	0	2	0	0	0	0	0
		CO2	Conclude the enabling technologies that drive the pervasive and ubiquitous computing	2	0	3	0	0	3	0	0	0	0	2	0
		CO3	Formulate the design aspects, that are essential to create the model of pervasive computing	2	0	2	0	0	3	0	0	0	0	3	0
		CO4	Develop solutions for problems related to pervasive and ubiquitous computing system through investigation	0	3	3	0	0	2	0	0	0	0	1	3
CSHO14	Virtualization Techniques	CO1	Suggest appropriate virtualization needs for an organization to maximize resource utilization	1	2	2	2	1	2	1	0	1	1	2	2
		CO2	Design the virtualization needs for any given organization	1	1	2	3	1	1	1	0	1	1	2	2

		CO3	Modify appropriate virtualization algorithms to suit any organization	1	3	2	2	1	1	1	0	0	1	2	2
		CO4	Identify the vulnerabilities in the organizations' infrastructure and provide security algorithms for virtualized resources	0	1	2	2	0	0	1	3	0	0	2	2
CSHO15	Randomized Algorithms	CO1	Learn the mathematical foundations emphasizing the design and analysis of randomized algorithm	2	2	1	0	3	2	0	0	0	0	0	0
		CO2	Apply basics of probability theory in the analysis of algorithms	1	0	2	0	2	0	0	0	0	0	2	0
		CO3	Comprehend randomized algorithms and its advantages to traditional algorithm	0	1	0	0	2	0	0	0	3	0	1	0
		CO4	Design and implement randomized techniques in solving real world problems and analyze their performance	3	0	3	0	1	2	0	0	0	0	1	0
CSHO16	Compiler Optimization	CO1	Apply the knowledge of LEX & YACC tool to develop a scanner & parser	2	0	1	0	0	3	0	0	0	3	0	2
		CO2	Design and develop software system for backend of the compiler	1	0	2	3	0	0	0	0	0	3	0	0
		CO3	Suggest the necessity for appropriate code optimization techniques	2	0	2	0	0	0	0	2	0	3	1	2

		CO4	Conclude the appropriate generator algorithm for a source language and design a compiler for any programming language	0	1	0	2	0	3	0	2	0	0	2	2
CSHO17	Fog & Edge Computing	CO1	Understand the key architectures and basic fundamentals of fog computing.	3	2	2	3	1	0	0	0	0	0	2	0
		CO2	Understand the challenges in fog computing.	2	3	2	2	3	0	0	0	0	0	2	0
		CO3	Perform fog and edge computing services.	1	2	3	2	1	2	3	0	1	1	3	1
		CO4	Understand the basic fundamentals of edge computing, use fog and edge computing services in various applications.	1	2	3	3	2	1	2	1	1	1	3	2
CSOH18	Quantum Safe Cryptography	CO1	Identify the difference between conventional and Lattice based cryptography protocols.	3	3	3	0	0	0	0	0	0	0	0	0
		CO2	Ability to break the Lattice based cryptosystem that is not secure.	3	2	2	0	0	3	2	0	0	0	0	0
		CO3	Derive simple provable security proofs for Lattice based schemes and quantum protocols.	3	2	2	0	2	2	1	2	0	0	2	2
		CO4	Design and implement quantum cryptographic protocols.	3	2	3	0	2	3	2	0	0	0	2	2

3 - High; 2 - Medium; 1 - Low

II SEMESTER

Course Code	CSPC11
Course Title	Discrete Structures
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment & End Assessment

Course Learning Objectives (CLO)

CLO1	To get familiar with and understand the fundamental notions in discrete mathematics
CLO2	To describe binary relations between two sets; determine if a binary relation is reflexive, symmetric, or transitive or is an equivalence relation; combine relations using set operations and composition
CLO3	To understand and demonstrate the basic concept of an algorithm and its application in combinatorial mathematics
CLO4	To identify the base step and the recursive or inductive step in applied problems and give a recursive and a non-recursive definition for an iterative algorithm
CLO5	To identify the basic properties of graphs and trees and model simple applications

Course Content

UNIT I Set Theory and Logic

Sets - Functions - Relations - Equivalence Relation - Poset - Functions Logic: Propositional Logic - Truth Tables - Tautologies - Resolution Proof System - Predicate Logic.

UNIT II Induction and Combinatorics

Peano's Axioms - Mathematical Induction - Pigeon Hole Principle - Principle of Inclusion and Exclusion - Review of Permutations and Combinations - Distribution Problems - Derangements - Bijection Principle.

UNIT III Algebraic Structures

Semi-Groups - Monoids - Groups - Subgroups and their properties - Cyclic groups - Cosets - Permutation Groups - Lagrange's Theorem - Cayley's Theorem - Normal Subgroups - Homomorphism of Groups - Quotient Groups - Introduction to Rings and Fields.

UNIT IV Linear Algebra and Recurrence relations

Linear Algebra: Vector space - Basis - Dimension - Orthogonally - Recurrence Relations: Homogenous and Inhomogenous - Recurrences and their solutions - Solving Recurrences using Generating functions.

UNIT V Graph Theory

Definitions and basic results - Representation of a graph by a matrix and Adjacency list - Trees - Cycles - Properties - Paths and Connectedness - Subgraphs - Graph Isomorphism - Operations on Graphs - Vertex and Edge cuts - Vertex and Edge connectivity.

Text Book

1. C. L. Liu, D. P. Mohapatra, "Elements of Discrete Mathematics: A Computer-oriented Approach", McGraw Hill, Third Edition, 2012.
2. Kenneth H. Rosen, "Discrete Mathematics and its Applications", Seventh Edition, McGraw Hill, 2012 *(Indian Adaptation by Kamala Krithivasan, IIT Madras)*.

References

1.	Narsing Deo, "Graph Theory with Applications to Engineering and Computer Science", Dover Publications Inc., First Edition, 2016
2.	George Tourlakis, "Discrete Mathematics: A Concise Introduction", First Edition, Springer International Publishing AG ,2024
3.	Martin Milanic, Brigitte Servatius, Herman Servatius, "Discrete Mathematics With Logic",Elsevier,2023.
4.	Richard J Trudeau, "Introduction to Graph Theory", Zaccheus Entertainment,2017

Course Outcomes (CO)

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

CO1	Distinguish between the notion of discrete and continuous mathematical structures
CO2	Prove basic set equalities
CO3	Apply induction and other proof techniques towards problem solving
CO4	Solve problems in Computer Science using graphs and trees

III SEMESTER

Course Code	CSPC31
Course Title	Principles of Programming Languages
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-2-4
Course Assessment Methods	Continuous Assessment & End Semester Assessment

Course Learning Objectives (CLO)

CO1	To understand the various ways to describe syntax, semantics, data types and basic statements of programming languages
CO2	To understand parameter passing and function call mechanisms
CO3	To understand object-orientation, concurrency, and event handling in programming languages
CO4	To acquire knowledge about functional and logic programming paradigms

Course Content:

UNIT I Syntax and Semantics and Basic Statements

Evolution of programming languages - describing syntax & semantics - lexical analysis - parsing - recursive-decent bottom up parsing - primitive data types – strings - array types - associative arrays - record types - union types - pointers and references - Arithmetic expressions - relational and Boolean expressions - assignment statements - mixed-mode assignments - control structures - selection - iterations - branching - guarded statements.

Lab Component (Exercises similar to the following):

1. Simple test programs to determine type compatibility rules of a C compiler.
2. Simple test program to determine the scope of variables having the same name and different names declared within a while / for loop.
3. Program that behaves differently if name equivalence is used against structural equivalence.
4. Write a program to convert one form of comments in C to alternate comments form.

UNIT II Subprograms and Implementations

Subprograms - design issues - local referencing - parameter passing - overloaded methods - generic methods - design issues for functions - semantics of call and return - implementing simple subprograms - stack - dynamic local variables - nested subprograms - blocks - dynamic scoping.

Lab Component (Exercises similar to the following):

1. Write a program to determine the ratio of the time required to pass a large array by reference and the time required to pass the same array by value.
2. Write a program that determines whether it is legal to call a function that has been passed by passing a pointer to it to another function.
3. Devise a subprogram and calling code in which pass-by-reference and pass-by-value-result of one or more parameters produces different results.
4. Design a skeletal program and a calling sequence that results in an activation record instance in which the static and dynamic links point to different activation recorded instances in the run-time stack.

UNIT III Object-Orientation, Concurrent, and Event Driven Programming

Object-orientation design issues for OOP languages - implementation of object-oriented constructs - concurrency - semaphores - monitors - message passing - threads - statement level concurrency - exception handling - Event driven control - Event Handling

Lab Component (Exercises similar to the following):

1. Chess / checkers game using object oriented programming – C++/Smalltalk / Python / Java.
2. Design a Tic-tac-toe game that uses even driven programming concepts.

The bouncing ball game is one where, there are more than 2 balls bouncing around a window. When the ball reaches the edge of a window, it reverses direction. Write program using concurrent programming concepts to implement this game. Try alternate ways of changing the ball's direction.

UNIT IV Functional Programming

Introduction to lambda calculus - fundamentals of functional programming languages - Programming with Scheme - Introduction to LISP - Lists - Storage allocation for lists - Some useful functions - Error handling.

Lab Component (Exercises similar to the following):

1. Scheme functions to compute mathematical formula, roots of a quadratic equation, count of characters in a string, set computation like, Union, Intersection, complementation, etc.
2. Lisp recursive function to return 'nth' item from a list, diagonal of a matrix, sum of the diagonal of matrix, a sub-string from a string, etc.

UNIT V Logic Programming

Introduction to logic and logic programming - Computing with relations - Programming with Prolog - Data structures in Prolog - Programming techniques - Control in Prolog - Cuts - multi-paradigm languages.

Lab Component (Exercises similar to the following):

1. Prolog program to find the factorial of a number, simplification of arithmetic expression involving additive, multiplicative identity, solve Sudoku puzzle, etc.

Text Books:

1. Robert W. Sebesta, "Concepts of Programming Languages", Tenth Edition, Addison Wesley, 2012.

2. Michael L. Scott, "Programming Language Pragmatics", Third Edition, Morgan Kaufmann, 2009.

Reference

1.	Allen B Tucker, and Robert E Noonan, "Programming Languages – Principles and Paradigms", Second Edition, TataMcGraw Hill, 2007.
2.	R. Kent Dybvig, "The Scheme Programming Language", Fourth Edition, MIT Press, 2009.
3.	Richard A. O'Keefe, "The Craft of Prolog", MIT Press, 2009.
4.	Kenneth Louden, Kenneth Lambert, "Programming Languages: Principles and Practices", Third Edition, Course Technology Inc; 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Define data types, functions, syntax and semantics of all programming languages
CO2	Use the various styles of programming languages for any given problem
CO3	Compare and use appropriate parameter passing technique for solving problems
CO4	Distinguish between the usage of all programming languages

Course Code	CSPC32
Course Title	Data Structures
Type of Course	PC
Prerequisites	CSPC11
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment & End Semester Asssessment

Course Learning Objectives (CLO)

CO1	To gain thorough knowledge about the basic data structures such as arrays, stacks and queues and their applications.
CO2	To design and implement various types of linked lists and explore their applications.
CO3	To acquire knowledge of complex structures such as AVL trees, red-black trees, and other types.
CO4	To Design and analyze efficient algorithms for sorting, searching, and graph traversal.

Course Content:

UNIT I Introduction

Development of Algorithms - Notations and analysis - Storage structures for arrays - Sparse matrices - Stacks and Queues: Representations and applications.

UNIT II Linked List, Stacks, and Queues

Linked Lists - Linked stacks and queues - Operations on polynomials - Doubly linked lists - Circularly linked lists - Dynamic storage management - Garbage collection and compaction.

UNIT III Trees

Binary Trees - Binary search trees - Tree traversal - Expression manipulation - Symbol table construction - Height balanced trees - AVL trees - Red-black trees.

UNIT IV Graphs

Graphs - Representation of graphs - BFS - DFS - Topological sort - String representation and manipulations - Pattern matching.

UNIT V Sorting and Searching

Sorting Techniques - Selection - Bubble - Insertion - Merge - Heap - Quick - Radix sort - Address calculation - Linear search - Binary search - Hash table methods.

Text Books:

1. J. P. Tremblay, P. G. Sorenson, “An Introduction to Data Structures with Applications”, Second Edition, Tata McGraw Hill, 1981.
2. M. Tenenbaum, Augestien, “Data Structures using C”, Third Edition, Pearson Education, 2007.

Reference Books:

1.	Sartaj Sahni, "Data Structures, Algorithms and Applications in C++", Universities Press (I) Pvt. Ltd., 2008
2.	Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Fourth Edition, Pearson, 2022. ISBN: 978-0132847377.
3.	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", Fourth Edition, MIT Press, 2022. ISBN: 978-0262046305.
4.	Narasimha Karumanchi, "Data Structures and Algorithms Made Easy: Data Structures and Algorithmic Puzzles", Fifth Edition, CareerMonk Publications, 2016.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply appropriate linear data structures such as stacks, queues, and linked lists in various applications.
CO2	Apply the concept of trees and graph data structures in real world scenarios
CO3	Appropriately to decide on the data structure for any practical problem
CO4	Comprehend the implementation of sorting and searching algorithms

Course Code	CSPC33
Course Title	Digital Systems Design
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To understand the overview on the design principles of digital computing systems
CO2	To learn the various number systems
CO3	To learn Boolean Algebra and Understand the various logic gates
CO4	To be familiar with various combinational circuits and designing using PLD

Course Content

UNIT I Boolean Algebra
Binary codes - Weighted and non-weighted Binary arithmetic conversion algorithms - Canonical and standard boolean expressions - Truth tables - K-map reduction - Don't care conditions - Adders / Subtractors - Carry look-ahead adder - Code conversion algorithms - Design of code converters - Equivalence functions.

UNIT II Combinational Circuits
Binary/Decimal Parallel Adder/Subtractor for signed numbers - Magnitude comparator - Decoders / Encoders - Multiplexers / Demultiplexers - Boolean function implementation using multiplexers.

UNIT III Sequential Circuits
Sequential logic - Basic latch - Flip-flops (SR - D - JK - T - Master-Slave) - Triggering of flip-flops - Counters - Design procedure - Ripple counters - BCD and Binary - Synchronous counters - Registers - Shift registers - Registers with parallel load - Reduction of state and flow tables - Race-free state assignment - Hazards.

UNIT IV VLSI Design
Introduction to VLSI design - Basic gate design - Digital VLSI design - Design of general boolean circuits using CMOS gates - Verilog Concepts - Basic concepts - Modules & ports & Functions - useful modelling techniques - Timing and delays - user defined primitives - Modelling Techniques.

UNIT V Advanced Concepts
Advanced Verilog Concepts - Synthesis concepts - Inferring latches and flip-flops - Modelling techniques for efficient circuit design - Design of high-speed arithmetic circuits - Parallelism Pipelined Wallace tree tipliers - Systolic algorithms - Systolic matrix multiplication.

Text Books:
1. Morris Mano, and Michael D. Ciletti, “Digital Design”, Fifth Edition, PHI, 2012.
2. Samir Palnitkar, “Verilog HDL”, Second Edition, Pearson Education, 2003.

Reference Books:

1.	Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL", Second Edition, Pearson Education, 2010.
2.	Stephen Brown, "Fundamentals of Digital Logic with Verilog", McGraw Hill, 2007.
3.	David Harris and Sarah Harris, "Digital Design and Computer Architecture", Second Edition, Morgan Kaufmann, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design a VLSI circuit for an application
CO2	Comprehend the digital design logic
CO3	Design and Analysis of a given digital circuit – combinational and sequential
CO4	Use Boolean simplification techniques to design a combinational hardware circuit

Course Code	CSPC34
Course Title	Computer Organization
Type of Course	PC
Pre-requisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CO1	To understand the basic hardware and software issues of computer organization
CO2	To understand the representation of data at machine level
CO3	To understand how computations are performed at machine level
CO4	To understand the memory hierarchies, cache memories and virtual memories
CO5	To learn the different ways of communication with I/O devices

Course Content:

UNIT I

Introduction - Technologies for building Processors and Memory - Performance - The Power Wall - Operations of the Computer Hardware - Operands Signed and Unsigned numbers - Representing Instructions - Logical Operations - Instructions for Making Decisions

UNIT II

MIPS Addressing for 32-Bit Immediates and Addresses - Parallelism and Instructions: Synchronization - Translating and Starting a Program - Addition and Subtraction - Multiplication - Division - Floating Point - Parallelism and Computer Arithmetic: Subword Parallelissm - Streaming SIMD Extensions and Advanced Vector Extensions in x86.

UNIT III

Logic Design Conventions - Building a Datapath - A Simple Implementation Scheme - overview of Pipelining - Pipelined Datapath - Data Hazards: Forwarding versus Stalling - Control Hazards - Exceptions - Parallelism via Instructions - The ARM Cortex–A8 and Intel Core i7 Pipelines - Instruction–Level Parallelism and Matrix Multiply Hardware Design language.

UNIT IV

Memory Technologies - Basics of Caches - Measuring and Improving Cache Performance - dependable memory hierarchy - Virtual Machines - Virtual Memory - Using FSM to Control a Simple Cache - Parallelism and Memory Hierarchy: Redundant Arrays of Inexpensive Disks - Advanced Material: Implementing Cache Controllers.

UNIT V

Disk Storage and Dependability - Parallelism and Memory Hierarchy: RAID levels - performance of storage systems - Introduction to multi threading clusters - message passing multiprocessors.

Text Books:

1. David A. Patterson, John L. Hennessey, “Computer Organization and Design, The Hardware/Software Interface”, Fifth Edition, Morgan Kauffman/Elsevier, 2014.
2. Smruti Ranjan Sarangi, “Computer Organization and Architecture”, McGraw Hill Education, 2015.

Reference Books:

1.	V. Carl Hamacher, Zvonko G. Varanesic, Safat G. Zaky, "Computer Organization", Sixth Edition, McGraw-Hill Inc., 2012.
2.	William Stallings, "Computer Organization and Architecture", Eighth Edition, Pearson Education, 2010
3.	Pranabananda Chakraborty ,"Computer Organisation and ArchitectureEvolutionary Concepts, Principles, and Designs", First Edition, 2020
4.	Linda Null , "Essentials Of Computer Organization And Architecture",5th, Jones and Bartlett Publishers,2018

Course Outcomes (CO)

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

CO1	Understand the architecture and functionality of central processing unit
CO2	Analyze the hardware and software issues and the interfacing
CO3	Work out the trade-offs involved in designing a modern computer system
CO4	Understand the various memory systems and I/O communication

Course Code	CSLR31
Course Title	Data Structures Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment & End Semester Examination

Course Learning Objectives (CLO)

CO1	To analyze the time and space complexities and efficiency of various algorithms
CO2	To understand the practical application of linear and nonlinear data structures
CO3	To introduce and practice advanced algorithms, programming techniques necessary for developing sophisticated computer application programs
CO4	To design, implement, and analyze advanced data structures and their operations, ensuring optimized performance and efficiency

Course Content:

Exercises

1. Develop and Implement a menu driven Program in C/C++/java program for the various kinds of Array operations.
2. Implement different ways of constructing stacks and queues (array/list implementation, stack using queues, queue using stack, etc.,)
3. Design and Implement stack applications such as expression validation, expression conversion, etc.,
4. Design and Implement different types of queue and their applications.
5. Implementation of Single linked list, double linked list and circular linked lists along with the various operations.
6. Implementation of Binary Tree, Binary Search Tree, traversal methods and their other operations.
7. Design and implement height biased binary trees such as AVL Trees and Red black trees.
8. Implementation of BFS, DFS using stack and queues.
9. Construct the Minimum spanning tree using different approaches
10. Implementation of various Sorting Techniques.

Text Books:

1. J. P. Tremblay, P. G. Sorenson, “An Introduction to Data Structures with Applications”, Second Edition, Tata McGraw Hill, 1981.
2. M. Tenenbaum, Augestien, “Data Structures using C”, Third Edition, Pearson Education, 2007.
3. Narasimha Karumanchi, “Data Structures and Algorithms Made Easy: Data Structures and Algorithmic Puzzles”, Fifth Edition, CareerMonk Publications, 2016.

Reference Books

1.	Sartaj Sahni, "Data Structures, Algorithms and Applications in C++", Universities Press (I) Pvt. Ltd., 2008
2.	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", Fourth Edition, MIT Press, 2022. ISBN: 978-0262046305.
3.	Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Fourth Edition, Pearson, 2022. ISBN: 978-0132847377.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze and compare various linear and non-linear data structures
CO2	Code, debug and demonstrate the working nature of different types of data structures and their applications
CO3	Implement, analyse, and evaluate the searching and sorting algorithms
CO4	Choose the appropriate data structure for solving real world problems

Course Code	CSLR32
Course Title	Digital Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To understand the overview on the design principles of digital computing systems.
CLO2	To learn Boolean Algebra and Understand the various logic gates.
CLO3	To develop programs in Hardware Description Language.
CLO4	To design and implement synchronous sequential, asynchronous sequential circuits.
CLO5	To be familiar with basic combinational and sequential components used in the typical data path designs.

Course Content:

1. Verification of Boolean Theorems using basic gates.
2. Design and implementation of combinational circuits for arbitrary functions and code converters.
3. Design and implement Adder and Subtractor.
4. Implement Parity generator / checker.
5. Design and implement combinational circuits: 4 –bit binary adder / subtractor.
6. Design and implement shift-registers.
7. Design and implement synchronous and asynchronous counters.
8. Coding sequential circuits using HDL.
9. Coding combinational circuits using HDL.
10. Design of a 32-bit carry look-ahead adder with logarithmic depth using Verilog.
11. Design of a Wallace tree multiplier using Verilog.
12. Design and implementation of board using Verilog.

Text Books:

1. Morris Mano, Michael D. Ciletti, “Digital Design”, Fifth Edition, PHI, 2012.
2. Samir Palnitkar, “Verilog HDL”, Second Edition, Pearson Education, 2003.

Reference Books:

1.	Michael D. Ciletti, “Advanced Digital Design with the Verilog HDL”, Second Edition, Pearson Education, 2010.
2.	Stephen Brown, “Fundamentals of Digital Logic with Verilog”, McGraw Hill, 2007.
3.	Farzin Asadi, “Digital Circuits Laboratory Manual”, 2024.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and develop basic digital systems.
CO2	Design synchronous sequential circuits using basic flip-flops, counters, PLA, PAL.
CO3	Debug digital circuits.
CO4	Use Boolean simplification techniques to design a combinational hardware circuit.

SEMESTER IV

Course Code	CSPC41
Course Title	Formal Languages and Automata Theory
Type of Course	PC
Prerequisites	CSPC11
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To know about Chomsky hierarchy for organizing languages
CLO2	To introduce concepts in automata theory and theory of computation
CLO3	To identify different formal language classes and their relationships
CLO4	To design grammars and recognizers for different formal languages and to understand undecidability and decide on languages that are undecidable.

Course Content:

UNIT I Finite Automata

Alphabets - Strings and Languages - Automata and Grammars - Deterministic Finite Automata (DFA) - Formal Definition - Simplified notation: State transition graph - Transition table - Language of DFA - Nondeterministic Finite Automata (NFA) - NFA with epsilon transition - Language of NFA - Equivalence of NFA and DFA - Minimization of Finite Automata - Distinguishing one string from other - Myhill-Nerode Theorem.

UNIT II Regular Expression (RE)

Definition - Operators of regular expression and their precedence - Algebraic laws for Regular expressions - Kleen's Theorem - Regular expression to FA - DFA to Regular expression - Arden Theorem - Non Regular Languages - Pumping Lemma for regular Languages. Application of Pumping Lemma - Closure properties of Regular Languages - Decision properties of Regular Languages - FA with output: Moore and Mealy machine - Equivalence of Moore and Mealy Machine - Applications and Limitation of FA.

UNIT III Context Free Grammar (CFG) and Context Free Languages

Definition - Examples - Derivation - Derivation trees - Ambiguity in Grammar - Inherent ambiguity - Ambiguous to Unambiguous CFG - Useless symbols - Simplification of CFGs - Normal forms for CFGs: CNF and GNF - Closure properties of CFLs - Decision Properties of CFLs: Emptiness - Finiteness and Membership - Pumping lemma for CFLs.

UNIT IV Push Down Automata (PDA)

Description and definition - Instantaneous Description - Language of PDA - Acceptance by Final state - Acceptance by empty stack - Deterministic PDA - Equivalence of acceptance by empty stack and final state - Conversion of CFG to PDA and PDA to CFG.

UNIT V Turing Machines (TM) and Undecidability

Basic model - definition and representation - Instantaneous Description - Language acceptance by TM - Variants of Turing Machine - TM as Computer of Integer functions - Universal TM - Church's Thesis - Recursive and recursively enumerable languages - Halting problem - Introduction to Undecidability - Undecidable problems about TMs - Post correspondence problem (PCP) - Modified PCP and undecidable nature of post correspondence problem - Introduction to recursive function theory.

Text Books

1. John Hopcroft, Rajeev Motwani, and Jeffrey Ullman, "Introduction to Automata Theory, Languages and Computation", Third Edition, Pearson Education, 2014.

Reference Books:

1.	John Hopcroft, Jeffrey Ullman, "Introduction to Automata Theory, Languages and Computation", Nineteenth Reprint, Narosa Publishing House, 2002.
2.	Martin J. C., "Introduction to Languages and Theory of Computations", Fourth Edition, TMH, 2010.
3.	Peter Linz, "An Introduction to Formal Language and Automata", Narosa Pub. House, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design finite automata or regular expression for any tokenization task
CO2	Construct a context free grammar for parsing any language
CO3	Design Turing machine and Conclude the decidable / undecidable nature of any language
CO4	Apply mathematical and formal techniques for solving real-world problems

Course Code	CSPC42
Course Title	Design and Analysis of Algorithms
Type of Course	PC
Prerequisites	CSPC32
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To understand the importance of algorithm
CLO2	To analyze the complexity of an algorithm in terms of time and space complexities
CLO3	To understand various problem solving techniques
CLO4	To learn about amortized analysis of algorithms
CLO5	To design and implement various programming paradigms and its complexity

Course Contents

UNIT I Introduction

Algorithms - Examples - Tournament method - Evaluating polynomial functions - pre-processing of coefficients - solving recurrence equations.

UNIT II Divide & Conquer and Greedy Approaches

Divide and Conquer method - Strassen's matrix multiplication - Greedy method - Huffman code - Minimum spanning trees - Dijkstra algorithm - Knapsack problem - Job sequencing with deadlines.

UNIT III Dynamic Programming Approaches

Dynamic Programming - Knapsack problem - Matrix Chain Multiplication - longest common subsequence Multistage graphs - All pair's shortest paths - Optimal binary search trees - Travelling salesman problem.

UNIT IV Amortization

Randomized Algorithms and Amortized Analysis - Las Vegas and Monte Carlo types - Randomized quick sort and its analysis - Min-Cut algorithm.

UNIT V NP Problems

NP-Hard and NP-complete problems - Basic concepts - Reducibility - Vertex cover-3 - CNF - clique - Hamiltonian cycle - TSP - Approximation algorithms - Vertex cover - TSP.

Text Book

1. T. Cormen, C. Lieserson, R. Rivest, C. Stein, "Introductions to Algorithms", Third Edition, Prentice-Hall/India, 2009.

Reference Books:

1.	M. Tenenbaum, Augestien, "Data Structures using C", Third Edition, Pearson Education, 2007.
2.	Sartaj Sahni, "Data Structures, Algorithms and Applications in C++", Universities Press Pvt. Ltd., 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze the time and space complexity for any algorithm
CO2	Apply the design techniques of algorithm in solving real world problems
CO3	Design randomized and dynamic programming based algorithms
CO4	Understand NP class of problems and propose approximation algorithms for the same

Course Code	CSPC43
Course Title	Operating Systems
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide knowledge about the services rendered by operating systems.
CLO2	To explore the various scheduling policies and to provide solutions for critical section and deadlock problems.
CLO3	To provide a detailed discussion of the various memory management techniques.
CLO4	To discuss the various file-system design and implementation issues.
CLO5	To explore the design and implementation issues of Distributed OS.

Course Content

UNIT I Introduction

Need for Operating Systems - Computer Systems - OS Operations - Abstract view of OS Virtualization - Computing Environments - OS Services - OS Structures - System Calls – Building and Booting OS - Process - Threads - Multithreading.

UNIT II Process Management

Process Scheduling - Process Co-ordination - Synchronization - Semaphores - Monitors – Hardware Synchronization - Deadlocks - Methods for Handling Deadlocks.

UNIT III Memory Management

Memory Management Strategies - Contiguous and Non-Contiguous allocation - Virtual memory Management - Demand Paging - Page Placement and Replacement Policies.

UNIT IV File Management

File System - Basic concepts - File System design and Implementation - Case Study: Linux File Systems - Mass Storage Structure - Disk Scheduling - Disk Management - I/O Systems - System Protection and Security.

UNIT V Distributed Systems

Distributed Systems - Distributed operating systems - Distributed file systems - Distributed Synchronization - OS architecture - Case study on LINUX and Windows OS.

Text Books:

1. Silberschatz, Galvin, Gagne, “Operating System Concepts”, Tenth Edition, John Wiley and Sons, 2018.
2. Andrew S. Tanenbaum, “Modern Operating Systems”, Fifth Edition, Pearson Publications, 2022.

Reference Books:

1.	William Stallings, "Operating Systems – Internals and Design Principles", Ninth Edition, Pearson Publications, 2018.
2.	Dhananjay M. Dhamdhere, "Operating Systems - A Concept-Based Approach", Third Edition, Tata McGraw Hill Education, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend the techniques used to implement the process manager.
CO2	Comprehend memory management techniques.
CO3	Design and develop file system and I/O system.
CO4	Design and develop OS modules for Distributed Environment.

Course Code	CSLR41
Course Title	Algorithms Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessments, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn how to analyze the complexity of algorithms
CLO2	To compare and evaluate algorithms in terms of time and space complexity
CLO3	To program brute force, divide and conquer, decrease and conquer, transform and conquer, greedy, and dynamic techniques

Course Content:

Exercises

1. Estimating worst-case/average-case complexity of algorithms via programs.
2. Determining machine constants.
3. Programs involving some advanced data structures.
4. Implementing example problems.
5. Illustrating the different paradigms of algorithm design.
6. Solving miscellaneous problems e.g. problems in string manipulation, graph theory, optimization.

Text Books:

1. H. S. Wilf, “Algorithms and Complexity”, Prentice Hall
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, “Introduction to Algorithms”, Prentice Hall.

Reference Books:

1.	Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, “Fundamentals of Computer Algorithms”, Second Edition, Universities Press, 2008
2.	Anany Levitin, “Introduction to the Design and Analysis of Algorithms, Pearson, Third Edition, 2012

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Solve and analyze general algorithms based on space and time complexity
CO2	Implement and empirically compare fundamental algorithms and data structures to real-world problems
CO3	Design, develop, and optimize algorithms in different paradigms
CO4	Implement advanced data structures

Course Code	CSLR42
Course Title	Operating Systems Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the concept of Operating System
CLO2	To have insight knowledge on different system calls and Unix Utilities
CLO3	To experience the practical side of the functioning of various blocks in OS
CLO4	To design a real world application by considering process synchronization, Memory management

Exercises

1. Hands on Unix Commands.
2. Shell programming for file handling.
3. Shell Script programming using the commands grep, awk, and sed.
4. Programs on Multithread using Pthread.
5. Implementation of CPU scheduling algorithms.
6. Implementation of Synchronization problems using Semaphores, Message Queues and Shared Memory.
7. Implementation of Memory Management - Allocation, Placement and replacement Algorithms.
8. Implementation of various Disk scheduling algorithms.

Text Books

1. Silberschatz, Galvin, Gagne, "Operating System Concepts", Ninth Edition, John Wiley and Sons, 2013.
2. William Stallings, "Operating Systems – Internals and Design Principles", Eighth Edition, Pearson Publications, 2014.

Reference Books

1. Behrouz A. Forouzan, and Richard F. Gilberg, "UNIX and Shell Programming: A Textbook", Brooks/ Cole-Thomson Learning, 2003.
2. Andrew S. Tanenbaum, "Modern Operating Systems", Fourth Edition, Pearson Publications, 2014.
3. Silberschatz, Galvin, Gagne,"Silberschatz's Operating System Concepts" ,Wiley India,2023

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Write program on shell script and Pthread
CO2	Solve synchronization problems
CO3	Compare and contrast various CPU scheduling algorithms, Memory allocation policy
CO4	Differentiate the disk scheduling algorithms

SEMESTER V

Course Code	CSPC51
Course Title	Computer Architecture
Type of Course	PC
Prerequisites	CSPC34
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To understand the concept of advanced pipelining techniques
CO2	To understand the current state of art in memory system design
CO3	To know the working principle of I/O devices
CO4	o understand the memory management techniques

Course Content:

UNIT I

Introduction - Classes of computers - Defining Computer Architecture - Trends in Technology - Trends in Power and Energy in Integrated Circuits - Trends in Cost - Dependability - Measuring - Reporting and Summarizing Performance - Quantitative Principles of Computer Design.

UNIT II

Basic and Intermediate pipelining Concepts - The Major Hurdle of Pipelining - Pipeline Hazards - Pipelining Implementation - Implementation issues that makes Pipelining hard - Extending the MIPS Pipeline to Handle Multicycle Operations - The MIPS R4000 Pipeline.

UNIT III

Instruction-Level Parallelism: Concepts and Challenges - Basic Compiler Techniques for Exposing ILP - Reducing Branch Costs with Prediction - Overcoming Data Hazards with Dynamic Scheduling - Dynamic Scheduling - Hardware-Based Speculation - Exploiting ILP Using Multiple Issue and Static Scheduling - Exploiting ILP - Advanced Techniques for Instruction Delivery and Speculation - Studies of the Limitations of ILP.

UNIT IV

Vector Architecture - SIMD Instruction Set Extensions for Multimedia - Graphics Processing Units - Detecting and Enhancing Loop-Level Parallelism - Centralized Shared-Memory Architectures - Performance of Shared-Memory Multiprocessors - Distributed Shared Memory - Models of Memory Consistency - Multicore Processors and their Performance.

UNIT V

Review of Memory Hierarchy Design - Cache Performance - Basic Cache Optimizations - Virtual Memory - Protection and Examples of Virtual Memory - Advanced Optimizations of Cache Performance - Memory Technology and Optimizations - Protection: Virtual Memory and Virtual Machines - Crosscutting Issues: The Design of Memory Hierarchies - Case Studies / Lab Exercises.

Text Books:

1. David. A. Patterson, John L. Hennessy, "Computer Architecture: A Quantitative approach", Sixth Edition, Elsevier, 2023
2. K. Hwang, Naresh Jotwani, "Advanced Computer Architecture, Parallelism, Scalability, Programmability", Second Edition, Tata McGraw Hill, 2010.

Reference Books:

1.	V. Carl Hamacher, Zvonko G. Varanesic, Safat G. Zaky, "Computer Organisation", Sixth Edition, McGraw Hill Inc, 2012.
2.	William Stallings "Computer Organization and Architecture", Seventh Edition, Pearson Education, 2006
3.	Vincent P. Heuring, Harry F. Jordan, "Computer System Architecture", Second Edition, Pearson Education, 2005

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply performance metrics to find the performance of systems.
CO2	Identify the program block that requires parallelism for any program.
CO3	Comprehend and differentiate various computer architectures and hardware.
CO4	Design algorithms for memory management techniques and Analyse the performance of a system

Course Code	CSPC52
Course Title	Database Management Systems
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment & End semester examination

Course Learning Objectives (CLO)

CLO1	To learn data models, conceptualize and depict a database system using ER diagram
CLO2	To understand the internal storage structures in a physical DB design
CLO3	To know the fundamental concepts of transaction processing techniques
CLO4	To understand the concept of Database Design in Normalization techniques
CLO5	To know the manipulation of SQL Queries

Course Content:

UNIT I Introduction

Purpose of Database System - Views of data - data models - database management system - three-schema architecture of DBMS - components of DBMS - E/R Model - Conceptual data modelling - motivation - entities - entity types - attributes - relationships - relationship types - E/R diagram notation - examples.

UNIT II Relational Model

Relational Data Model - Concept of relations - schema-instance distinction - keys - referential integrity and foreign keys - relational algebra operators - SQL - Introduction - data definition in SQL - table - key and foreign key definitions - update behaviours - Querying in SQL - notion of aggregation - aggregation functions groupby and having clauses - embedded SQL.

UNIT III Database Design

Dependencies and Normal forms - dependency theory - functional dependencies - Armstrong's axioms for FD's - closure of a set of FD's - minimal covers - definitions of 1NF - 2NF - 3NF and BCNF - decompositions and desirable properties of them - algorithms for 3NF and BCNF normalization - 4NF and 5NF.

UNIT IV Transactions

Transaction processing and Error recovery - concepts of transaction processing - ACID properties - concurrency control - locking based protocols for CC - error recovery and logging - undo - redo - undo-redo logging and recovery methods.

UNIT V Implementation Techniques

Data Storage and Indexes - file organizations - primary and secondary index structures - various index structures - hash-based dynamic hashing techniques - multi-level indexes - B+ trees.

Text Books:

1. Silberschatz, Henry F. Korth, S. Sudharshan, “Database System Concepts”, Fifth Edition, Tata McGraw Hill, 2006.
2. J. Date, A. Kannan, S. Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

Reference Books:

1.	Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Pearson/Addision Wesley, Fourth Edition, 2007.
2.	Raghu Ramakrishnan, "Database Management Systems", McGraw Hill, Third Edition, 2003.
3.	S. K. Singh, "Database Systems Concepts, Design and Applications", Pearson Education, First Edition, 2006.
4.	Monelli ayyavaraiah, "Database management system", Horizon books, 2017

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Master the basics of SQL and construct queries using SQL
CO2	Design and develop a large database with optimal query processing
CO3	Develop efficient storage scheme of saving and retrieving Records and Files
CO4	Design the database with normalization techniques

Course Code	CSPC53
Course Title	Computer Networks
Type of Course	PC
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessments, End Assessment

Course Learning Objectives (CLO)

CO1	To provide insight about fundamental concepts and reference models (OSI and TCP/IP) and its functionalists
CO2	To gain comprehensive knowledge about the physical layer functions and spread spectrum techniques.
CO3	To know the implementation of various error control techniques, channel access protocols and routing protocols.
CO4	To able to understand the working principles of TCP, UDP and application layer protocols.

Course Content

UNIT I
Introduction to computer networks: Network Component and Categories - Topologies - Transmission Media - Reference Models: ISO/OSI Model and TCP/IP Model.

UNIT II
Physical Layer: Digital and Analog Signals - Periodic Analog Signals - Transmission Impairments - Digital data transmission techniques - Analog data transmission techniques - Multiplexing and Spread Spectrum.

UNIT III
Data Link Layer: Error Detection and Correction - Parity - LRC - CRC - Hamming Code - Flow Control and Error Control - Stop and wait - ARQ - Sliding window - HDLC - Multiple Access Protocols - CSMA - CSMA/CD and CSMA/CA - IEEE 802.3 Ethernet.

UNIT IV
Network Layer: Packet Switching and Datagram approach - IP Addressing methods - Subnetting - Routing - Distance Vector Routing - RIP - Link State Routing - OSPF - BGP - Multicast Routing - MOSPF - DVMRP - Broadcast Routing.

UNIT V
Transport Layer: Transport Services - UDP - TCP - Congestion Control - Quality of Services (QOS) - Application Layer: Domain Name Space (DNS) - Electronic Mail - WWW - Cryptography Techniques.

Text Books:

1. Andrew S. Tanenbaum, David J. Wetherall, “Computer Networks”, Fifth Edition, Prentice Hall, 2011.
2. James F. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, Eighth Edition, Pearson, 2020.
3. Behrouz A. Forouzan, “Data Communications and Networking”, Fifth Edition, McGraw-Hill Education, 2012.

Reference Books:

1.	William Stallings, "Data and Computer Communications", Pearson Education, Eleventh Edition, 2021.
2.	Douglas E. Comer, "Internetworking with TCP/IP, Vol 1: Principles, Protocols, and Architecture", Pearson, Sixth Edition, 2013

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Gain insight about basic network theory and layered communication architectures.
CO2	Able to resolve the medium access and routing problems under various scenarios.
CO3	Implement TCP and UDP protocols with better QoS support for the real time applications.
CO4	Propose algorithms at the appropriate layer for any communication network task.

Course Code	CSPC54
Course Title	Introduction to Artificial Intelligence and Machine learning
Type of Course	PC
Prerequisites	CSPC11
Contact Hours	L-T-P-C : 3-0-2-4
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CO1	To learn the concepts of searching for AI problems
CO2	To learn about agents and knowledge representation
CO3	To understand the various factors involved in inferences
CO4	To get introduced to fundamentals of machine learning
CO5	To learn about the possibilities of Supervised and Unsupervised learning

Course Content:

UNIT I

AI - History of AI - Agents - Structure of Intelligent agents - Environments - Problem solving methods – Problem solving agents - Formulating problems - search strategies - Breadth-first - Uniform cost - Depth-first - Depth-limited - Bidirectional - Informed Search - Best-first Heuristic Functions - Memory bounded search - A* - SMA* - Iterative Improvement algorithms - Hill Climbing - Simulated annealing - Measure of performance and analysis of search algorithms.

Lab Component (Exercises similar to the following):

1. Heuristics and search strategy for Travelling salesperson problem.

2. Implement n-queens problem using Hill-climbing, simulated annealing, etc.

UNIT II

Game playing - Perfect Decisions - Imperfect Decisions - Alpha-beta pruning - Knowledge based agent - Wumpus World Environment - Propositional logic - agent for wumpus world - First order logic - syntax - semantics - extensions - Using First order logic - Representation change in the world - Goal based agents.

Lab Component (Exercises similar to the following):

1. Tic-tac-toe game simulation using search and heuristics.
2. Solve 3-SAT, 3-CNF algorithms using agents.
3. Describe the Sudoku game and represent the actions using First-order / Propositional logic.

UNIT III

Knowledge Base - Knowledge representation - Production based system - Frame based system - Inference - Backward chaining - Forward chaining.

Lab Component (Exercises similar to the following):

1. Sorting algorithms employing forward chaining.
2. Logical reasoning examples for E-commerce stores using forward/backward chaining.

UNIT IV

Learning from agents - inductive learning - Types of Machine learning - Supervised learning - learning decision trees - support vector machines - Neural and Belief networks - Perceptron - Multi-layer feed forward networks - Bayesian belief networks.

Lab Component (Exercises similar to the following):
1. Study of Machine learning tool.
2. Exercises on decision trees, SVM using the tool.

UNIT V

Unsupervised learning - K-means clustering - hierarchical clustering - Agglomerative and Divisive clustering - Fuzzy clustering.

Lab Component (Exercises similar to the following):
1. K-means clustering implementation using tool.
2. Agglomerative, divisive, fuzzy clustering using tool.

Text Books

1. Stuart Russel, Peter Norvig, "AI – A Modern Approach", Second Edition, Pearson Education, 2007.
2. Kevin Night, Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill, 2008.

Reference Books:

1.	Vinod Chandra SS, Anand Hareendran S, "Artificial and Machine Learning", First Edition, PHI Learning, 2014.
2.	Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007.
3.	Tom Mitchell, "Machine Learning", First Edition, Tata McGraw Hill India, 2017.
4.	Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow", O'Reilly Media, 3rd Edition, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Suggest appropriate search strategies for any AI problem
CO2	Design agents for any given problem
CO3	Represent real world knowledge using first order or propositional logic
CO4	Solve problems by appropriated using the supervised or unsupervised machine learning algorithms

Course Code	CSLR51
Course Title	Database Management Systems Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment, Model Lab, End Semester

Course Learning Objectives (CLO)

CLO1	To explore and understand the features of a Database Management Systems
CLO2	To interface a database with front end tools
CLO3	To understand the internals of a database system
CLO4	To identify Structure Query Language statements used in creation and manipulation of Database
CLO5	To identify the methodology of conceptual modelling through Entity Relationship model

Course Content:

Exercises

1. Working with DDL, DML and DCL.
2. Inbuilt functions in RDBMS.
3. Nested Queries & Join Queries.
4. Set operators & Views in SQL.
5. Control structures.
6. Working with Procedures and Functions.
7. Working with Triggers in MySQL.
8. Dynamic & Embedded SQL.
9. Working with XML.
10. Working with PHP and MySQL
11. Working with Python and MySQL
12. Working with CRUD operations in MongoDB
13. Database Design and implementation (Mini Project).

Text Books:

1. Silberschatz, Henry F. Korth, S. Sudharshan, "Database System Concepts", 7th Edition, Tata McGraw Hill, 2019.
2. C. J. Date, A. Kannan, S. Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.

Reference Books:

1.	Raghu Ramakrishnan, Johannes Gehrke, "Database Management Systems", Third Edition, Mc Graw Hill, 2014
2.	Hector Garcia-Molina, Jeffrey Ullman, Jennifer Widom, "Database Systems: The Complete Book" Second Edition, Pearson, 2008
3.	Elmasri Ramez, Navathe Shamkant, "Fundamentals of Database Management Systems" 7th Edition, Pearson Education, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify Structure Query Language statements used in creation and manipulation of Database and comprehend the internal working of a database system
CO2	Use databases for building client server applications
CO3	Design and develop a database using SQL and the mechanism in connecting with a Web based GUI
CO4	Analyze and design a real database application

Course Code	CSLR52
Course Title	Networks Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessments, End Assessment

Course Learning Objectives (CLO)

CO1	To create client and server applications using the "Sockets" API and the implementation of Data link layer protocol and TCP layer
CO2	To conduct computer communication network simulations.
CO3	To have hands-on experience in computer network simulation and modelling techniques using NS-3/python/MATLAB or any simulation software.

Exercises:

1. Exercises on Socket Programming using C and Java
2. Exercises using NS-3 or any other network simulator.
    a. Basics of Network Simulation
        - Introduction, Platform required to run network simulator, Backend Environment of Network Simulator, Agents and applications, Tracing
    b. Simulating a Local Area Network
        - Local Area Network, LAN Topologies, MAC Protocol, Taking turns, Ethernet, Ethernet Frame Structure, Ethernet Versions, Simulating a LAN using Network Simulator3
        - Implementation of various MAC protocols
        - Setting up of various network topologies
        - Measurement of routing protocols
    c. Measuring Network Performance
        - Network Performance Evaluation, Performance Evaluation Metrics, Parameters Affecting the Performance of Networks, Performance Evaluation Techniques, Network Performance Evaluation using NS-3
        - Setting up of network that carries various application protocols and analyzing the performances
3. Hands on experiments on Network equipments.
    a. Switches, Routers
    b. Hardware firewall

Text Books:

1. W. Richard Stevens, “UNIX Network Programming – Networking APIs: Sockets and XTI”, Prentice Hall, Vol. 1, Second Edition, 1998.
2. Eitan Altman, Tania Jimenez, “NS Simulator for Beginners”, Morgan & Claypool Publishers, 2011.

Reference Books

1	Jack L. Burbank, “An Introduction to Network Simulator 3”, Wiley-Blackwell, First Edition, 2015.
2	Kenneth L. Calvert, Michael J. Donahoo. “TCP/IP Sockets in Java: Practical Guide for Programmers”, Morgan Kaufmann Publisher, Second Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Implement client-server applications using Sockets.
CO2	Invoke analytical studies of Computer Networks through network simulation.
CO3	Design a network using NS-3 toolkit and its importance in designing a real network.
CO4	Measure and analyze the network parameters for a high throughput network.

SEMESTER VI

Course Code	**CSPC61**
Course Title	**Embedded Systems Architectures**
Type of Course	PC
Prerequisites	CSPC51
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To understand basics of Embedded Systems Architecture
CLO2	To understand the intricacies of Embedded programming
CLO3	To develop programs in embedded systems of real time scenarios
CLO4	To solve real time computational problems with embedded system architectures

Course Content

Unit I Introduction to Embedded System

Introduction - A Systems Engineering Approach to Embedded System Design - Architecture - Importance - System model - Programming Languages and Examples - Standards and Networking - Multiple standards-based device.

Unit II Embedded Hardware: Hardware Building Blocks

The Embedded Board and the Von-Neumann Model - Basic Hardware Materials: Embedded Processors - ISA Architecture Models - Internal processor design - Processor Performance - Memory - Board I/O - Board Buses - Component Interfacing.

Unit III Embedded Software: Device Drivers

Interrupt - Handling - Memory Device Drivers - On-board Bus Device Drivers - Examples - Embedded Operating Systems - Process - Multitasking and Process Management - I/O and File System Management.

Unit IV OS for Embedded Systems

Process - Multitasking and Process Management - POSIX - OS Performance Guidelines - selecting right OS's and Board Support Packages (BSPs) - Middleware and Application Software - Development Tools for Embedded System - Embedded C programming.

Unit V Design, Development and Case studies

Creating an Embedded System Architecture - Implementation and Testing - Implementing the Design - Quality Assurance and Testing of the Design - Debugging - System Level Performance Analysis - Maintaining the Embedded System - Embedded GPU Design - Embedded Computing System on FPGAs - Hardware-Software Co-design - Embedded Systems Security - Typical Case Studies: Automotive Driver Assistance - Mobile Agents for Embedded System.

Text Books:

1. Tammy Noergaard, "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers", Second Edition, Elsevier Embedded Technology Series, Newnes Publication, 2012.
2. Krzysztof Iniewski, "Embedded Systems: Hardware, Design, and Implementation", Wiley & Sons, Inc. Edited, 2013.
3. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Third Edition, McGraw Hill Education (India), 2014.

Reference Books:

1.	Julio Sanchez, Maria P. Canton, "Embedded Systems Circuits and Programming", Taylor and Francis, 2012.
2.	J. Staunstrup, Wayne Wolf, "Hardware/Software Co-Design: Principles and Practice", Prentice Hall.
3.	Wayne Wolf, "Computers as Components - Principles of Embedded Computer System Design", Morgan Third Edition, Kaufmann Publishers, 2012.
4.	Daniele Lacamera, Embedded Systems Architecture: Design and write software for embedded devices to build safe and connected systems, Second Edition 2024

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Ability to comprehend the architecture of Embedded systems
CO2	Ability to design and develop programs for specific embedded applications
CO3	Understand operating systems for embedded systems
CO4	Understand about life cycle of embedded design and its testing

Course Code	CSPC62
Course Title	Compiler Design
Type of Course	PC
Prerequisites	CSPC41
Contact Hours	L-T-P-C : 3-0-2-4
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the major concept areas in compiler design and know the various phases of the compiler
CLO2	To understand the various parsing algorithms and comparison of the same
CLO3	To provide practical programming skills necessary for designing a compiler
CLO4	To gain knowledge about the various code generation principles
CLO5	To understand the necessity for code optimization

Course Content:

UNIT I Introduction to Compilation

Compilers - Analysis of the source program - Phases of a compiler - Cousins of the Compiler Grouping of Phases - Compiler construction tools - Lexical Analysis - Role of Lexical Analyzer - Input Buffering - Specification of Tokens.

Lab Component: Tutorial on LEX / FLEX tool, Tokenization exercises using LEX.

UNIT II Syntax Analysis

Role of the parser - Writing Grammars - Context-Free Grammars - Top Down parsing – Recursive Descent Parsing - Predictive Parsing - Bottom-up parsing - Shift Reduce Parsing – Operator Precedent Parsing - LR Parsers - SLR Parser - Canonical LR Parser - LALR Parser.

Lab Component: Tutorial on YACC tool, Parsing exercises using YACC tool.

UNIT III Intermediate Code Generation

Intermediate languages - Declarations - Assignment Statements - Boolean Expressions - Case Statements - Back patching - Procedure calls.

Lab Component: A sample language like C-lite is to be chosen. Intermediate code generation exercises for assignment statements, loops, conditional statements using LEX/YACC.

UNIT IV Code Optimization and Run Time Environments

Introduction - Principal Sources of Optimization - Optimization of basic Blocks – DAG representation of Basic Blocks - Introduction to Global Data Flow Analysis - Runtime Environments - Source Language issues - Storage Organization - Storage Allocation strategies - Access to non-local names - Parameter Passing - Error detection and recovery.

Lab Component: Local optimization to be implemented using LEX/YACC for the sample language.

UNIT V Code Generation

Issues in the design of code generator - The target machine - Runtime Storage management – Basic Blocks and Flow Graphs - Next-use Information - A simple Code generator – DAG based code generation - Peephole Optimization.

Lab Component: DAG construction, Simple Code Generator implementation, DAG based code generation using LEX/YACC for the sample language.

Text Books:

1.	Alfred V. Aho, Jeffrey D Ullman, "Compilers: Principles, Techniques and Tools", Pearson Education Asia, 2012.
2.	Jean Paul Tremblay, Paul G Serenson, "The Theory and Practice of Compiler Writing", BS Publications, 2005.
3.	Dhamdhere, D. M., "Compiler Construction Principles and Practice", Second Edition, Macmillan India Ltd., New Delhi, 2008.

Reference Books:

1.	Allen I. Holub, "Compiler Design in C", Prentice Hall of India, 2003.
2.	C. N. Fischer, R. J. LeBlanc, "Crafting a compiler with C", Benjamin Cummings, 2003
3.	Henk Alblas, Albert Nymeyer, "Practice and Principles of Compiler Building with C", PHI, 2001.
4.	Kenneth C. Louden, "Compiler Construction: Principles and Practice", Thompson Learning, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply the knowledge of LEX & YACC tool to develop a scanner and parser
CO2	Design and develop software system for backend of the compiler
CO3	Suggest the necessity for appropriate code optimization techniques and conclude the appropriate code generator algorithm for a given source language
CO4	Design a compiler for any programming language

Course Code	CSPC63
Course Title	Principles of Cryptography
Type of Course	PC
Prerequisites	CSPC63
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To gain knowledge about the mathematics of the cryptographic algorithms
CLO2	To get an insight into the working of different existing cryptographic algorithms
CLO3	To learn about key exchange protocols and attacks on such protocols
CLO4	To introduce the fundamental concepts of hash functions and digital signatures
CLO5	To learn how to use cryptographic algorithms in security

Course Content

UNITI Mathematical Foundations
Number Theory: Fermat's theorem - Cauchy 's theorem - Chinese remainder theorem - Primality testing algorithm - Euclid's algorithm for integers - quadratic residues - Legendre symbol - Jacobi symbol.*

UNIT II Classical Cryptosystems
Cryptography and cryptanalysis - Classical Cryptography - different type of attack: CMA - CPA - CCA - Shannon perfect secrecy - OTP - Pseudo random bit generators - stream ciphers and RC4.*

UNIT III Symmetric Key Ciphers
Block ciphers: Modes of operation - DES and its variants - finite fields (2^n) - AES - linear and differential cryptanalysis.*

UNIT IV Asymmetric Key Ciphers
One-way function - trapdoor one-way function - Public key cryptography - RSA cryptosystem - Diffie-Hellman key exchange algorithm - ElGamal Cryptosystem.*

UNIT V Message Authentication
Cryptographic hash functions - secure hash algorithm - Message authentication - digital signature - RSA digital signature.*

*Programming assignments are mandatory.

Text Books

1. Stinson. D., “Cryptography: Theory and Practice”, Fourth Edition, Chapman & Hall/CRC, 2018.
2. W. Stallings, “Cryptography and Network Security Principles and practice”, Seventh Edition, Pearson Education Asia, 2017.

References

1.	W. Mao, "Modern Cryptography: Theory & Practice", Pearson Education, 2004.
2.	Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", Eighth Edition, Tata McGraw Hill, 2023.
3.	Thomas Koshy, "Elementary Number Theory with Applications", Elsevier India, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basic concepts of symmetric cryptosystem, public key cryptosystem and digital signature scheme
CO2	Ability to break the cryptosystem that is secure
CO3	Evaluate the security of a protocol based on security metrics
CO4	Justify the usage of security principles and digital signatures for any application

Course Code	CSLR61
Course Title	Embedded Systems Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce embedded systems design tools
CLO2	To write programs to interface the memory and I/Os with processors
CLO3	To program and test the ARM processor-based circuits and their interfaces
CLO4	To implement the basic building blocks of a microcontroller including counters, I/O techniques and requirements, A/D conversion

Course Content:

1. To interface LED and perform the flashing of LEDs with ARM processor using mbed LPC 1768.
2. To create a waveforms using ARM processor using mbed LPC 1768 and display it using CRO.
   a. Triangular waveform
   b. Square waveform
   c. Saw-tooth waveform
3. To interface the DC motor with ARM processor using mbed LPC 1768 and perform the speed control.
4. To write and read data from EEPROM interfaced with ARM processor.
5. To interface LCD with ARM processor and display the text.
6. To implement SISO and PISO using Zybo board.
7. To implement SIPO and PIPO using Zybo board.
8. To implement 3-bit Counters in Zybo board.
   a. Ring Counter
   b. Johnson counter
9. To interface temperature sensor with Raspberry Pi.
10. To interface humidity sensor with Raspberry Pi.
11. To interface RFID sensor with Raspberry Pi.
12. To interface convert Analog signal in digital form using 3 – bit ADC in Zedboard.
13. To interface and convert Digital to Analog using 3 – bit DAC in Zedboard.
14. To interface external memory with Zedboard.
15. To interface monitor and external source with Zedboard.

Text Books:

1. Jonathan W. Valvano, “Embedded Systems: Real-Time Interfacing to Arm® Cortex™-Microcontrollers”, CreateSpace Independent Publishing Platform, 2nd Edition, 2012.
2. Joseph Yiu, “The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors”, Newnes, 3rd Edition, 2013.

Reference Books:

1.	Simon Monk, "Programming the Raspberry Pi: Getting Started with Python", McGraw-Hill Education TAB, 2nd Edition, 2015.
2.	Pong P. Chu, "FPGA Prototyping by VHDL Examples: Xilinx MicroBlaze MCS SoC", Wiley, 2nd Edition, 2017.
3.	David Harris and Sarah Harris, "Digital Design and Computer Architecture", Morgan Kaufmann, 2nd Edition, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Assemble and troubleshoot hardware devices
CO2	Write programs for interfacing keyboard, display, motor, and sensor
CO3	Design and program an embedded system at the basic level
CO4	Write programs in ARM for a specific Application

Course Code	CSLR62
Course Title	App Development Laboratory
Type of Course	ELR
Prerequisites	-
Contact Hours	L-T-P-C : 0-0-3-2
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To be familiar with Web page design using HTML/XML and style sheets
CLO2	To learn to write Client Server applications
CLO3	To be familiar with the PHP programming and be exposed to create applications with AJAX
CLO4	Know the components and structure of mobile application development frameworks for Android and windows OS based mobiles

Course Content

Exercises

A. Web Applications

1. Create a web page for user registration using HTML, CSS and validate the details using Javascript.
2. Write programs in Java using Servlets: (i) To invoke servlets from HTML forms; (ii) Session tracking using hidden form fields and Session tracking for a hit count.
3. Create three-tier applications using JSP 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.
4. Create a database with user information and books information and create a webpage in which books catalogue should be dynamically loaded from the database using AJAX.
5. Create and save an XML document at the server, which contains 10 users Information. Write a Program, which takes user Id as an input and returns the User details by taking the user information from the XML document.
6. Develop email verification application using PHP.

B. Mobile Applications

1. Design restaurant data entry form using Table Layout and show different events using activity class.
2. Write a program to capture image using built in camera and store it in database.
3. Develop a banking application that registers the user by verifying OTP.
4. Develop a native application that uses GPS location information and convert into speech.
5. Write a program to call a number.

Text Books

1. Reto Meier, “Professional Android 4 Application Development”, Wrox, 2012.
2. Matt Gifford, “PhoneGap Mobile Application Development Cookbook”, Packt, 2012.

Reference books

1.	Adrian Kosmaczewski, "Mobile JavaScript Application Development", O'Reilly, 2012.
2.	Thomas Powell, "HTML & CSS: The Complete Reference", McGraw Hill Education, 2017.
3.	Raimon Rafols Montane, Laurence Dawson, "Learning Android Application Development", Packt Publishing, 2016.

Course Outcomes (CO)

At the end of the course student will be able to

CLO1	Construct Web pages using HTML/XML and style sheets
CLO2	Build dynamic web pages with validation using Java Script objects and by applying different event handling mechanisms
CLO3	Develop Web application which makes use of PHP and AJAX programming
CLO4	Deploy applications to hand-held devices

Course Code	CSIR41
Course Title	Professional Ethics
Type of Course	GIR
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	Identify the core values that shape the ethical behavior of an engineer
CLO2	To create an awareness on professional ethics and human values
CLO3	To introduce loyalty, moral and social values
CLO4	To develop as a competent and trust worthy professionals
CLO5	To enable the students to appreciate the rights of others

Course Contents

UNIT I Human Values

Morals - Values and Ethics - Integrity - Work Ethic - Service Learning - Civic Virtue Respect for others - Living Peacefully - Caring - Sharing - Honesty - Courage - Valuing time - Co-operation - Commitment - Empathy - Self-confidence - Character - Spirituality - The role of engineers in modern society - Social expectations.

UNIT II Engineering Ethics

Sense of 'Engineering Ethics' - Variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and Controversy - Models of Professional Roles & Professionalism - theories about right action - Self-interest - customs and religion - uses of ethical theories.

UNIT III Engineering as Social Experimentation

Engineering as experimentation - engineers as responsible experimenters - Research ethics - Codes of ethics - Industrial Standard - Balanced outlook on law - the challenger case study.

UNIT IV Safety, Responsibilities and Rights

Safety and risk - assessment of safety and risk - Riysis - Risk benefit analysis and reducing risk - Govt. Regulator's approach to risks - the three mile island and Chernobyl case studies & Bhopal Threat of Nuclear Power - depletion of ozone - greenery effects - Collegiality and loyalty - respect for authority - collective bargaining - Confidentiality - conflicts of interest - occupation crime - professional rights - employees' rights - Intellectual Property Rights (IPR) - discrimination.

UNIT V Global Issues

Multinational corporations - Business ethics - Environmental ethics - computer ethics - Role in Technological Development - Weapons development - engineers as managers - consulting engineers - engineers as expert - witnesses and advisors - Honesty - Leadership - sample code of conduct ethics like ASME - ASCE - IEEE - Institution of Engineers (India) - Indian Institute of Materials Management - Institution of Electronics and Telecommunication Engineers (IETE India).

Text Books:

1. Mika Martin, Roland Scinger, "Ethics in Engineeering", Pearson Education/Prentice Hall, New York, 1996.
2. Govindarajan M., Natarajan S., Senthil Kumar V. S., "Engineering Ethics", Prentice Hall of India, New Delhi, 2004.

Reference Books:

1.	Charles D. Fleddermann, "Ethics in Engineering", Pearson Education/Prentice Hall, New Jersey, 2004.
2.	Charles E. Harris, Michael S. Protchard, Michael J. Rabins, "Engineering Ethics – Concept and Cases", Wadsworth Thompson Learning, United States, 2000.
3.	Arthur A. Thompson et al., "Strategic Management: Concepts and Cases", McGraw-Hill Higher Education, 2000.
4.	John R. Boatright, "Ethics and Conduct of Business", Pearson Education, New Delhi, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understood the core values that shape the ethical behavior of an engineer
CO2	Expose awareness on professional ethics and human values
CO3	Demonstrate universally accepted ethical standards
CO4	Gain adequate knowledge about moral leadership and code of conduct

PROGRAMME ELECTIVES

II year Electives (Programme Elective – I, II, III)

Course Code	CSPE01
Course Title	Combinatorics and Graph Theory
Type of Course	PE
Prerequisites	CSPC11
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To explore several concepts of combinatorics
CLO2	To understand the applications of generating functions
CLO3	To describe Euler's formula, Hamilton paths, planar graphs and coloring problem
CLO4	To practice useful algorithms on networks such as shortest path algorithm, minimal spanning tree algorithm, and max-cut algorithm

Course Content:

UNIT I

Introduction to combinatorics - permutation of multisets - Combinations of Multisets - distribution of distinct objects into distinct cells - distribution of non-distinct objects into distinct cells - Shamire secret sharing - Catalan number - Principle of inclusion and exclusion - Derangement.

UNIT II

Generating functions - Partitions of integer - Ferrer graph - Solving recurrence relations using generating functions - Generating permutations and combinations - Pigeonhole principle: simple and strong Form - A Theorem of Ramsey.

UNIT III

Graph - simple graph - graph isomorphism - incidence and adjacency matrices - Haveli-Hakimi criterion - Subgraphs Tree – Minimum-cost spanning tree – Kruskal's algorithm- Prim's algorithm - Cayleys' formula – Kirchoff's Matrix-tree Theorem - Fundamental circuits - Algorithms for fundamental circuits - Cut-sets and Cut-vertices - fundamental cut-sets.

UNIT IV

Euler graph - Fleury's algorithm - Hamiltonian graph - Planar and Dual Graphs - Kuratowski's graphs Coloring - Greedy coloring algorithm - chromatic polynomial.

UNIT V

Mycielski's theorem – Matching, Halls marriage problem - Independent set - Dominating set – Vertex cover - clique - approximation algorithms.

Text Books:

1. Ralph P. Grimaldi, "Discrete and Combinatorial Mathematics", Fifth Edition, PHI/Pearson Education, 2004.
2. G. Chartrand, P. Zhang, "Introduction to Graph Theory", McGraw-Hill, 2006.

Reference Books:

1.	Kenneth H. Rosen, “Discrete Mathematics and its Applications”, Seventh Edition, McGraw Hill, 2012.
2.	D. S. Chandrasekharaiah, “Graph Theory and Combinatorics”, Prism, 2005.
3.	Douglas B. West ,"Combinatorial Mathematics" , Cambridge University Press, 2020
4.	Bikash Kanti Sarkar, Swapan Kumar Chakraborty, “Combinatorics and Graph Theory”, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend the fundamentals of combinatorics and apply combinatorial ideas in mathematical arguments in analysis of algorithms, queuing theory, etc.
CO2	Solve problems using generating functions
CO3	Design real-time applications as graph problems using graph theory fundamentals
CO4	Solve several graph problems which have practical significance.

Course Code	CSPE02
Course Title	Software Engineering
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the Software Engineering Practice
CLO2	To understand the Software Engineering Process Models
CLO3	To understand Design Engineering, Web applications
CLO4	To gain knowledge of the software testing
CLO5	To understand Software Project Management

Course Content

UNIT I

Introduction: Role of Software Engineer - Software Components - Software Characteristics - Software Crisis - Software Engineering Processes - Similarity and Differences from Conventional Engineering Processes - Quality Attributes.

Assessment: How Software Engineering Changes? Software Development Life Cycle (SDLC) Models: Water Fall Model, Prototype Model, Spiral Model, Evolutionary Development Models, Iterative Enhancement Models, Choosing a social relevant problem, Summary Team Report.

UNIT II

Requirement Engineering Process: Elicitation - Analysis - Documentation - Review and Management of User Needs - Feasibility Study - Information Modeling - Data Flow Diagrams - Entity Relationship Diagrams - Designing the architecture.

Assessment: Impact of Requirement Engineering in their problem, Decision Tables, SRS Document, IEEE Standards for SRS, Architectural design, component level design, user interface design, WebApp Design, Submission of SRS Document for Team Project.

UNIT III

Quality concepts - Review techniques - Software Quality Assurance (SQA): Verification and Validation - SQA Plans - Software Quality Frameworks.

Assessment: Framing SQA Plan, ISO 9000 Models, SEI-CMM Model and their relevance to project Management, other emerging models like People CMM.

UNIT IV

Testing Objectives - Unit Testing - Integration Testing - Acceptance Testing - Regression Testing - Testing for Functionality and Testing for Performance - Top-Down and Bottom-Up Testing - Software Testing Strategies - Strategies: Test Drivers and Test Stubs - Structural Testing (White Box Testing) - Functional Testing (Black Box Testing) - Testing conventional applications - object oriented applications - Web applications - Formal modeling and verification - Software configuration management - Product metrics.

Assessment: Team Analysis in Metrics Calculation.

UNIT V

Project Management Concepts - Process and Project Metrics - Estimation for Software projects - Project Scheduling - Risk Management - Maintenance and Re-engineering. Assessment: Preparation of Risk mitigation plan.

Text Book

1. R. S. Pressman, "Software Engineering: A Practitioners Approach", Seventh Edition, McGraw Hill, 2010.
2. Rajib Mall, "Fundamentals of Software Engineering", Third Edition, PHI Publication, 2009.
3. Pankaj Jalote, "Software Project Management in Practice", Pearson Education, New Delhi, 2002.

Course Outcomes (CO)

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

CO1	Assess each module given the overall Software engineering practice
CO2	Comprehend the systematic methodologies involved in SE
CO3	Design and develop a software product in accordance with SE principles
CO4	Design risk mitigation plans for software products.

Course Code	CSPE03
Course Title	Design Thinking
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand processes that enhances innovation activities
CLO2	To develop capabilities to identify problems/issues/needs
CLO3	To develop sound hypotheses, collect and analyze appropriate data
CLO4	To translate broadly defined opportunities into actionable innovation possibilities
CLO5	To understand Software Project Management

Course Content

UNIT I
Design Thinking - Introduction - What - How - Why - Design Process - Four Questions - Ten Tools - Identify an Opportunity - Scope your opportunity - Draft your design brief.

UNIT II
Three visualizations - Visualization basics - Journey mapping - Value Chain analysis - Mind mapping.

UNIT III
Design Criteria - Design thinking brainstorming - Concepts development - develop concepts - napkin pitches.

UNIT IV
Assumption testing - Rapid Prototyping - Surface Key assumptions - make prototypes.

UNIT V
Customer co-creation - learning launch - Feedback from stake holders - Design the on-ramp - Case study.

Text Book

1. Jeanne Liedtka, Tim Ogilvie, Rachel Brozenske, “The Designing for Growth Field Book: A Step-by Step Project Guide”, New York: Columbia University Press, 2014.
2. Jeanne Liedtka, Tim Ogilvie, “Designing for Growth: A Design Thinking Tool Kit for Managers”, New York: Columbia University Press, 2011.

Course Outcomes (CO)

At end of the course, students will be able to

CO1	Convert real-life problems into methodical problems
CO2	Apply various visualization principles for problem and solution representation
CO3	Design solutions by the applying an integrated approach to design thinking
CO4	Understanding customer feedback

Course Code	CSPE04
Course Title	Advanced Data Structures and Algorithms
Type of Course	PE
Prerequisites	CSPC31
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To explore various heaps
CLO2	To study the need for various balanced and multimedia tree structures
CLO3	To study about geometric algorithms and their applications
CLO4	To understand the approximation algorithms for the various NP complete problems
CLO5	To study about the various string matching algorithms

Course Contents

UNIT I

Binomial Heaps - Deaps - Leftist Heaps - Fibonacci Heaps – Operations – insert - delete - meld - find min.

UNIT II

Splay Trees - Point trees - Quad trees - K-d trees - TV-trees - Segment trees.

UNIT III

Dynamic programming - Optimal Binary search trees - TSP - Graph coloring - Knapsack problem - Backtracking algorithms - N-queens - Hamiltonian cycle - Graph coloring - Branch and bound method – Knapsack - TSP.

UNIT IV

Number-theoretic algorithms - FFT - String matching algorithms - KMP - Rabin-Karp - Boyer Moore algorithms.

UNIT V

Computational Geometry - convex hull - NP Complete problems - Reducibility - Vertex cover– clique - Hamiltonian cycle - TSP.

Text Books

1. H. S. Wilf, “Algorithms and Complexity”, Prentice Hall.
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, “Introduction to Algorithms”, Third Edition, Prentice Hall, 2012.

Reference Books:

1.	Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Second Edition, Universities Press, Reprint 2017.
2.	Subrahmanian, "Principles of Multimedia Database systems", First Edition, Elsevier, 2008

Course Outcomes (CO)

At end of the course, students will be able to

CO1	Apply the appropriate data structure for solving real-world problems
CO2	Apply the appropriate data structure for solving real-world problems
CO3	Appreciate the backtracking and branch and bound technique to solving NP problems
CO4	Analyse geometric problems and NP-complete problems and demonstrate the impact of reducibility on the real time problems.

Course Code	CSPE05
Course Title	Multimedia Systems
Type of Course	PE
Pre-requisites	-
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the different media and design issues in multimedia systems
CLO2	To understand communication standards for Multimedia
CLO3	Exploration of security for multimedia systems

Course Contents

UNIT I Multimedia Elements

Introduction - Definitions - Applications - Elements - Text - Image/Graphics Audio - Video - Animation.

UNIT II Audio and Speech

Data acquisition - sampling and quantization - human speech - digital model of speech production - analysis and synthesis - psychoacoustics - low bit rate speech compression - MPEG audio compression.

UNIT III Images and Video

Image acquisition and representation - bi-level image compression standards: ITU (formerly CCITT) Group III and IV standards - JPEG image compression standards - MPEG - H.264/AVC video compression standards - Transcoding.

UNIT IV Multimedia Networks

Protocol - QOS Issues - RTP - RTCP - RTSP - SIP - Media on demand - ITV - STB Broadcast Schemes for VoD Buffer Management - Multimedia over wireless networks.

UNIT V Multimedia Security and Forensics

Multimedia encryption - Digital Watermarking Security Attacks - Digital Forensics taxonomy - goals/ requirements - Forensic Data Acquisition - Forensics Analysis and Validation.

Text Books

1. K. Andleigh, Kiran Thakrar, “Multimedia Systems Design”, PHI, 2007.
2. ZeNian Li, S. Drew, “Fundamentals of Multimedia”, PHI, 2006.
3. Ze-Nian Li, Mark S. Drew, “Fundamentals of Multimedia”, Pearson Prentice Hall, 2004.

Reference Books:

1.	Jerry D. Gibson, Toby Berger, Tom Lookabaugh, Dave Lindergh, Richard L. Baker, "Digital Compression for Multimedia: Principles and Standards", Elsevier, 2006.
2.	Ralf Steinmetz, Klara, "Multimedia Computing, Communications and Applications", Pearson Education, 2009.
3.	Chun-Shien Lu, "Multimedia Security: Steganography and Digital Watermarking Techniques for Protection of Intellectual Property", Springer Inc., 2007.
4.	Wenjun Zeng, Heather Yu, Ching, Yung Lin, "Multimedia Security Technologies for Digital Rights Management", Elsevier Inc., 2006.

Course Outcomes (CO)

At end of the course, students will be able to

CO1	Design multimedia components and develop integrated, collaborative multimedia systems
CO2	Understand various compression standards and techniques in multimedia
CO3	Understand protocols for multimedia
CO4	Develop security algorithms for the specialized applications

Course Code	CSPE06
Course Title	Computing Algorithms based on Indian Knowledge Systems
Type of Course	PE
Pre-requisites	-
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the background of mathematical concepts developed in Indian Origin.
CLO2	Understand the application of mathematical methods in various aspects.
CLO3	Understand the benefits of these methods in view of efficient algorithm design.

Course Content:

UNIT 1:

Historical Background of main branches of mathematics - Arithmetic, Bija Grantham (Algebra), Geometry, Trigonometry, Introduction to Vedic Ganitham, Ganitha Sutras, Upa-sutras and its explanation- Dwayanka (Binary) of Maharishi Pingalacharya – 16 sutras of the binary system given in Chanda Sastram.

Prastara - Nashtam – Udistham - Samkhya - Advayoga - Eka dvi adi la ga kriya - Other minor pratyayas

UNIT 2:

Addition, subtraction - Multiplication algorithms - Ekanyunena Purvena (By one less than one before) - Ekadhikena Purvena (By one more than one Before) - Antyayordashakeapi - Nikhilam (Base 10, 100 and 1000) - Urdhvatriyakbhyam - Square - Anurupyena Method - Sankalana-vyavakalana Method - Yavadhunam Tavadhunikritya - Vargamcha Yojayet - DwandaYog - Square-root – Vilokanam - Dwandayog - Cube Anurupyena Method - Yavadhunam Tavadhunikritya Vargamcha Yojayet - Cube-root – Vilokanam.

UNIT 3:

A glimpse of Ancient Indian Ganitam - Sulaba Sutras -Boudhayana Theorem -Verification of Boudhayana Theorem-Value of $\sqrt{2}$ in Boudhayana Sulva sutra – Aryabhatta- Varahamihra – Bhrahmagupta - Bhaskaracharya -2, Vinculum Numbers (Runaank)- Method of knowing the vinculum numbers and its application.

UNIT 4:

Division – Dhawajaank – Nikhilam – Paravartya - Divisibility – Osculation, Recurring decimal, Auxiliary fraction.

UNIT 5:

Develop Algorithms based on- Bharatiya Ganitam & Chanda-Shastra-based algorithms – A case study for simple operations – A case study for complex operations - Comparison with currently implemented algorithms.

Text Books:

1. Vedic Maths – Swami Bharathi Krsna Theertha, Mothilal Banarasi Das, NewDelhi.
2. Vedic Maths Nirdeshika – Part1, 2, Vidya Bharathi, Samskrit Siksha Samsthan, Kurukshetra.

Reference Books:

1. Bharath ki Pramuk Ganitacharya, Vidya Bharathi, Samskrit Siksha Samsthan, Kurukshetra.
2. Vyavaharish Kaghol Parichaya, Vidya Bharathi, Samskrit Siksha Samsthan, Kurukshetra.
3. Bharatiya Ganita Pravesha Part One, a Primer to Indian Mathematics, Samskrit Promotion Foundation, Delhi
4. Bharatiya Ganita Pravesha Part Two, Samskrit Promotion Foundation, Delhi

Reference Books:

1.	Datta B and Singh A. N., History of Hindu Mathematics, 2 vols., Lahore 1935, 1938 (repr. Asia Publishing House, Bombay 1962; repr. Bharatiya Kala Prakashan, Delhi 2004).
2.	S. Balachandra Rao, Indian Mathematics and Astronomy, Bharatiya Vidya Bhavan, Bangalore, 1994.
3.	C. N. Srinivasiengar, The History of Ancient Indian Mathematics, The World Press Private Limited, Calcutta, 1988.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Ability to understand the necessity and importance of mathematical concepts of Indian origin.
CO2	Ability to develop and apply mathematical formulas based on Indian Mathematics text.
CO3	Ability to relate the mathematical formulae of Indian origin in a real-life situation.
CO4	Ability to compare the performances of conventional computing algorithms with algorithms based on Indian mathematical concepts

Stream I (Modern Computing Paradigms)

Course Code	CSPE11
Course Title	Real-Time Systems
Type of Course	PE
Prerequisites	CSPC43
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study issues related to the design and analysis of systems with real-time constraints
CLO2	To study the various Uniprocessor and Multiprocessor scheduling mechanisms
CLO3	To learn about various real-time communication protocols
CLO4	To study the difference between traditional and real-time databases

Course Content:

UNIT I Introduction to Real-time systems

Introduction to real time computing - Concepts - Example of real-time applications - Structure of a real time system - Characterization of real time systems and tasks - Hard and Soft timing constraints - Design Challenges - Performance metrics - Prediction of Execution Time: Source code analysis - Micro–architecture level analysis - Cache and pipeline issues - Programming Languages for Real-Time Systems.

UNIT II Task Assignment and Scheduling

Real time OS - Threads and Tasks - Structure of Microkernel - Time services - Scheduling Mechanisms - Communication and Synchronization - Event Notification and Software interrupt - Uniprocessor scheduling algorithms - Task assignment - Mode changes - Fault tolerant scheduling. *

UNIT III Real–Time Communication

Network topologies and architecture issues - Protocols - Contention-based - token–based - polled bus - Fault tolerant routing. *

UNIT IV Real–Time Databases

Transaction priorities and aborts - Concurrency control issues - Scheduling algorithms Two-phase approach to improve predictability. *

UNIT V Programming Languages and Tools

Hierarchical decomposition - Run–time error handling - Overloading - Timing specification - Recent trends and developments. *

*Programming Assignments are mandatory.

Text Books:

1. C. M. Krishna, Kang G. Shin, “Real–Time Systems”, International Edition, McGraw Hill Companies Inc., New York, 1997.
2. Jane Liu, “Real–Time Systems”, First Edition, Prentice Hall, 2002.

Reference Books:

1.	Rajib Mall, "Real–Time Systems: Theory and Practice", First Edition, Pearson Education, 2012.
2.	Hermann Kopetz, "Real-Time Systems: Design Principles for Distributed Embedded Applications", Springer, 2nd Edition, 2011.
3.	Alan Burns and Andy Wellings, "Real-Time Systems and Programming Languages: Ada, Real-Time Java and Real-Time POSIX", Addison-Wesley, 4th Edition, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyse scheduling problems
CO2	Develop real-time systems
CO3	Understand basic multi-task scheduling algorithms
CO4	Understanding tools and utilizing them for real-time environment

Course Code	CSPE12
Course Title	Cloud Computing
Type of Course	PE
Pre-requisites	-
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an in-depth and comprehensive knowledge of the deployment models in Cloud Computing
CLO2	To understand the enabling technologies needed for establishing cloud environment
CLO3	To motivate students to do programming and experiment with the various cloud computing environments
CLO4	To shed light on the cloud providers and software platforms
CLO5	To introduce about different programming models in cloud computing

Course Content:

UNIT I Introduction

Evolution: Clustering - Grid computing – Virtualization – Basic concepts - Benefits and Risks - Roles and Boundaries - Characteristics - XaaS based service offerings - Basic Deployment models.

UNIT II Enabling Technologies

Networks: ISPs - Connectionless Packet Switching - Router-based Interconnectivity - Technical and Business Considerations - Data Center: Standardization and Modularity - Automation - Remote Operation - High Availability - Hardware Virtualization: Hardware Independence - Server Consolidation - Resource Replication - OS and hardware based Virtualization - Web Technology - Multitenant Technology - Service Technology.

UNIT III Computing Mechanisms

Infrastructure: Logical Network Perimeter - Virtual Server - Storage Device - Usage Monitor - Resource Replication - Specialized: Automated Scaling Listener - Load Balancer - Monitors - Failover System - Hypervisor - Resource Cluster - Multi-Device Broker - State Management Database - Management: Resource - SLA - Billing - Remote Administration - Security.

UNIT IV Cloud Providers & Software Platforms

Globally available public clouds (Microsoft Azure - Amazon Web Services - Google Cloud Platform): Overview and Comparison - Instances - Images - Networking and Security - Storage - Monitoring and Automation -Introduction to Open-source software's: Eucalyptus - OpenNebula - OpenStack - Apache CloudStack.

UNIT V Programming Models & Advances

Introduction to MapReduce - Apache Spark - TensorFlow - Intercloud: Architecture - Resource Provisioning - Billing - Security - Mobile Cloud Computing: Resource Allocation - Security - Business Aspects - Application - Future Scope - Introduction to Edge and Fog Computing.

Text Books:

1. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, "Distributed and Cloud Computing from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier, 2012.

Reference Books:

1.	Barrie Sosinsky, "Cloud Computing Bible", John Wiley & Sons, 2010.
2.	Tim Mather, Subra Kumaraswamy, Shahed Latif, "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance", O'Reilly, 2009.
3.	James Turnbull, "The Docker Book: Containerization is the New Virtualization", E-Book, 2015.
4.	Krishna P Venkata," Principles of grid computing: concepts and applications", 1st, Delhi Ane Books Pvt. Ltd.,2015

Course Outcomes (CO)

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

CO1	Articulate the concepts, technologies, and applications of cloud computing
CO2	Identify cloud computing architecture and infrastructure, and apply appropriate computing mechanisms for cloud environments.
CO3	Provide the appropriate cloud computing solutions and recommendations according to the applications
CO4	Gain knowledge on recent advances and implementation of programming modes in cloud computing

Course Code	CSPE13
Course Title	Design and Analysis of Parallel Algorithms
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand different parallel architectures and models of computation
CLO2	To introduce the various classes of parallel algorithms
CLO3	To study parallel algorithms for basic problems
CLO4	To study graph Algorithms

Course Content

UNIT I Introduction to Parallel Computers

Need for parallel processing - SM-SIMD algorithms - Shared memory SIMD - Tree and mesh interconnection computers - Classifying MIMD Algorithms - parallel computational models such as PRAM - LMCC - Hypercube - Cube Connected Cycle - Butterfly - Perfect Shuffle Computers - Tree model - Pyramid model - Fully Connected model - PRAM - CREW - EREW models - simulation of one model from another one.

UNIT II Matrix Operations and Performance Measures

Matrix operations - Mesh transpose - Shuffle transpose - EREW transpose - Mesh multiplication - Cube multiplication - Matrix by vector multiplication - Tree multiplication - Performance Measures of Parallel Algorithms - speed-up and efficiency of PA - Cost optimality - An example of illustrate Cost-optimal algorithms such as summation - Min/Max on various models.

UNIT III Selection and Sorting

Sequential algorithm - Parallel Sorting Networks - Algorithm for parallel selection - Sorting on a linear array - broadcasting a datum - Computing all sums - Sorting on a mesh - Sorting on EREW SIMD computer - enumeration sort - parallel quick sort - hyper quick sort - Sorting on other networks - Parallel Merging Algorithms on CREW/EREW/MCC/ - Parallel Sorting Networks on CREW/EREW/MCC.

UNIT IV Searching and Numerical Problems

Parallel Searching Algorithm - Kth element - Kth element in X+Y on PRAM - Parallel Matrix Transportation and Multiplication Algorithm on PRAM - MCC - Vector-Matrix Multiplication - Solution of Linear Equation - Root finding - SIMD algorithm - Roots of nonlinear equations - MIMD algorithm - Partial differential equations - Computing Eigen values - Monte Carlo methods - parallel random number generators - random number distributions.

UNIT V Graph Problems

Definitions - Graph coloring - Computing the connectivity matrix - Finding connected components - search and traversal - Minimal alpha-beta tree - Minimum Cost Spanning Tree - Addition tree - Multiplication tree - Combinatorial Algorithms - Permutation - Combinations - Derangements.

Text Book

1. M. J. Quinn, “Designing Efficient Algorithms for Parallel Computer”, McGraw Hill,1987
2. S. G. Akl, “Design and Analysis of Parallel Algorithms”, PHI, 1989.

References

1.	J. Jaja, "An Introduction to Parallel Algorithms", Addison Wesley, 1992.
2.	F. T. Leighton, "Introduction to Parallel Algorithms and Architectures: Arrays, Trees", Morgan Kaufmann Publishers In, 1991.
3.	F. Thomson Leighton, "Introduction to Parallel Algorithms and Architectures: Arrays · Trees. Hypercubes", Morgan Kaufmann Publishers, San Mateo, California, 1992.

Course Outcomes (CO)

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

CO1	Develop parallel algorithms for standard problems and applications
CO2	Explain and derive the complexity of algorithms for basic and collective communication operations
CO3	Apply different methods and performance measures to analyze algorithms with respect to cost and scalability
CO4	Perform design and analysis of parallel algorithms in real-time applications

Course Code	CSPE14
Course Title	Parallel Architectures and Programming
Type of Course	PE
Prerequisites	CSPC51
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamental principles involved in designing modern parallel computers
CLO2	To understand the operation of parallel hardware including cache coherence and distributed memory machines
CLO3	To understand the necessity of efficient parallel program design to minimize overhead
CLO4	To gain knowledge about various parallel programming strategies

Course Content:

UNIT I Introduction

Introduction: The need for parallelism - Forms of parallelism (SISD - SIMD - MISD -MIMD) Moore's Law and
Multi-cores - Fundamentals of Parallel Computers - Communication architecture - Message passing architecture Data parallel architecture - Dataflow architecture - Systolic architecture - Performance Issues. *

UNIT II Cache Design

Large Cache Design: Shared vs. Private Caches - Centralized vs. Distributed Shared Caches - Snooping-based cache coherence protocol - directory-based cache coherence protocol - Uniform Cache Access - Non-Uniform Cache Access - D-NUCA - S-NUCA - Inclusion - Exclusion - Difference between transaction and transactional memory - STM - HTM. *

UNIT III Graphics Processing Unit

Graphics Processing Unit: GPUs as Parallel Computers - Architecture of a modern GPU - Evolution of Graphics Pipelines - GPGPUs - Scalable GPUs - Architectural characteristics of Future Systems - Implication of Technology and Architecture for users - Vector addition - Applications of GPU. *

UNIT IV Parallel Programming

Introduction to Parallel Programming: Strategies - Mechanism - Performance theory - Parallel Programming Patterns: Nesting pattern - Parallel Control Pattern - Parallel Data Management - Map: Scaled Vector - Mandelbrot - Collative: Reduce - Fusing Map and Reduce - Scan - Fusing Map and Scan - Data Recognition: Gather - Scatter - Pack - Stencil and Recurrence - Fork-Join - Pipeline. *

UNIT V Parallel Programming Languages

Parallel Programming Languages: Distributed Memory Programming with MPI: trapezoidal rule in MPI - I/O handling - MPI derived data type - Collective Communication - Shared Memory Programming with Threads: Conditional Variables - read-write locks - Cache handling - Shared memory programming with Open MP: Parallel for directives - scheduling loops - Thread Safety - CUDA: Parallel programming in CUDA C - Thread management - Constant memory and Event - Graphics Interoperability - Atomics - Streams.*

*Programming assignments are mandatory.

Text Books:

1. D. E. Culler, J. P. Singh, A. Gupta, "Parallel Computer Architecture", Morgan-Kaufmann, 2004
2. Rajeev Balasubramanian, Norman P. Jouppi, and Naveen Murali Manohar, "Multi-Core Cache Hierarchies", Morgan & Claypool Publishers, 2011.
3. Peter, Pach Eco, "An Introduction to Parallel Programming", Elsevier, 2011.
4. James R. Larus, Ravi Rajwar, "Transactional Memory", Morgan & Claypool Publishers, 2007

Reference Books:

1.	David B. Kirk, Wen-Mei, W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", 2010
2.	Barbara Chapman, F. Desprez, Gerhard R. Joubert, Alain Lichnewsky, Frans Peters, "Parallel Computing: From Multicores and GPU's to Petascale", 2010.
3.	Michael McCool, James Reinders, Arch Robison, "Structured Parallel Programming: Patterns for Efficient Computation", 2012.
4.	Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General-Purpose GPU Programming", 2011.
5.	Hockney, Roger W., and Chris R. Jesshope. Parallel Computers 2: architecture, programming and algorithms. CRC Press, 2019.
6.	Herlihy, M., Shavit, N., Luchangco, V., & Spear, M. (2020). The art of multiprocessor programming. Newnes

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend parallel architecture and its importance in solving engineering problem
CO2	Summarize and differentiate the different parallel programming strategies
CO3	Design parallel programs to enhance machine performance in parallel hardware environment
CO4	Design and write programs that can make efficient use of multiple cores, multiple networked processors and GPU Processing power

Course Code	CSPE15
Course Title	GPU Computing
Type of Course	PE
Prerequisites	CSPC51
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment & End semester examination

Course Learning Objectives (CLO)

CLO1	To learn the architecture of GPU and basics of parallelism
CLO2	To learn about the evolution of GPU computing
CLO3	To learn GPU programming using CUDA
CLO4	To study the methods of performance improvement in GPU

Course Content:

UNIT I Introduction

Graphics Processing Units (GPU) as Parallel Computers - Architecture of a modern GPU - Why more speed or parallelism? - Parallel Programming Languages and Models - Overarching Goals - History of GPU computing - Evolution of Graphics Pipelines - GPU Computing.

UNIT II Parallel Programming

Goals of Parallel Programming - Problem Decomposition - Algorithm Selection - Computational Thinking - Introduction to OPENCL: Background - Data Parallelism Model - Device Architecture - Kernel Functions - Device Management & Kernel Launch.

UNIT III Introduction to CUDA

Data Parallelism - CUDA Program Structure - A Matrix - Matrix Multiplication Example - Device Memories and Data Transfer - Kernel Functions and Threading - Function declarations - Kernel launch - Predefined variables - Runtime API - CUDA Threads: CUDA Thread Organization - Using blocked and threaded - Synchronization and Transparent Scalability - Thread Assignment - Thread Scheduling and Latency Tolerance - CUDA Memories: Importance of Memory Access Efficiency - CUDA Device Memory Types - A Strategy for Reducing Global Memory Traffic - Memory as a Limiting Factor to Parallelism.

UNIT IV Performance considerations

Thread execution - Global memory bandwidth - Dynamic partitioning of SM resources - Data prefetching - Instruction mix - Thread Granularity - Floating Point considerations: FP format - Representable numbers - Special bit patterns and precision - Arithmetic accuracy and rounding - Algorithm considerations - Debugging and Profiling: Debugging CUDA programs - Profiling CUDA programs - CUDA and MPI.

UNIT V Parallel Programming

Parallel Programming and Computational Thinking - Goals of Parallel Programming - Problem Decomposition - Algorithm Selection - Computational Thinking - OpenCL – Introduction

Text Books:

1. 1.David Kirk, Wen-mei Hwu, “Programming Massively Parallel Processors: A Hands-on Approach”, Third Edition, Morgan Kaufmann, 2017.

Reference Books:

1.	Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing)", First Edition, Morgan Kaufmann, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the basics of GPU architecture & programs using CUDA and OpenCL
CO2	Develop parallel applications targeting GPUs
CO3	Develop Debugging tool
CO4	Analyse the performance of the memory and thread execution in view of parallel programming

Course Code	CSPE16
Course Title	Internet of Things – Principles and Practices
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand Smart Objects and IoT Architectures
CLO2	To learn about various IOT-related protocols
CLO3	To build simple IoT Systems using Arduino and Raspberry Pi
CLO4	To understand data analytics and cloud in the context of IoT
CLO5	To develop IoT infrastructure for popular applications

Course Contents

UNIT I Fundamentals of IoT

Evolution of Internet of Things - Enabling Technologies - IoT Architectures: oneM2M - IoT World Forum (IoTWF) and Alternative IoT models - Simplified IoT Architecture and Core IoT Functional Stack - Fog - Edge and Cloud in IoT - Functional blocks of an IoT ecosystem - Sensors - Actuators - Smart Objects and Connecting Smart Objects.

UNIT II IoT Protocols

IoT Access Technologies: Physical and MAC layers - topology and Security of IEEE 802.15.4 - 802.15.4g - 802.15.4e - 1901.2a - 802.11ah and LoRaWAN - Network Layer: IP versions - Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo - Routing over Low Power and Lossy Networks - Application Transport Methods: Supervisory Control and Data Acquisition - Application Layer Protocols: CoAP and MQTT.

UNIT III Design and Development

Design Methodology - Embedded computing logic - Microcontroller - System on Chips - IoT system building blocks - Arduino Board details - IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.

UNIT IV Data Analytics and Supporting Services

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest - Role of Machine Learning - No SQL Databases - Hadoop Ecosystem - Apache Kafka - Apache Spark - Edge Streaming Analytics and Network Analytics - Xively Cloud for IoT - Python Web Application Framework - Django AWS for IoT - System Management with NETCONF-YANG.

UNIT V Case Studies / Industrial Applications

Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plantwide Ethernet Model (CPwE) - Power Utility Industry - GridBlocks Reference Model - Smart and Connected Cities: Layered architecture - Smart Lighting - Smart Parking Architecture and Smart Traffic Control.

Text Book

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.

Reference Books

1.	Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A Hands-on Approach”, Universities Press, 2015.
2.	Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things – Key Applications and Protocols”, Wiley, 2012 (for Unit 2).
3.	Jan Holler et al., “From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence”, Elsevier, 2014.
4.	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011.

Course Outcomes

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

CO1	Explain the concept of IoT and analyze various protocols for IoT
CO2	Design a PoC of an IoT system using Rasperry Pi/Arduino
CO3	Apply data analytics and use cloud offerings related to IoT
CO4	Analyze applications of IoT in real time scenario

Course Code	CSPE17
Course Title	Quantum Computing
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles of quantum computation and mechanics
CLO2	To learn about the operators involved in Quantum computing and their applications
CLO3	To study the information theory aspects of quantum computing
CLO4	To explore the various error corrections available for quantum computing
CLO5	To understand the principles of quantum computation and mechanics

Course Content

UNIT I

Review of Linear Algebra: Vector Space, Hilbert Space, Bases, Matrices, Eigenvalues and Eigen vectors, Hermitian matrices, Unitary matrices.

Introduction to Quantum Computing. Dirac Notation, Qubits, Bloch Sphere, Postulates of Quantum Mechanics, Classical Computation Vs Quantum Computation.

UNIT –II

Measurements: Composite system, reduced state, mixed state. Single Qubit gates – two qubit gates – Multiple Qubits gates, Universal gates, Quantum circuit model of computation, Quantum computational complexity-no cloning theorem.

UNIT III

Introduction to Quantum Simulator (Qiskit): Explore gates and circuits with Quantum composer, Programming using Qiskit.

Entanglement, Bell's inequality circuit on two and three qubits, Quantum parallelism, Quantum teleportation, Super-dense coding.

UNIT IV

Phase kick-back, Deutsch algorithm, Deutsch-Jozsa algorithm, Simon algorithm, Quantum Foruier Transform, Grover's quantum search algorithm, Shor's algorithm.

UNIT V

Quantum key distribution. Comparison Between Classical and Quantum Information Theory, Applications of Quantum Information.

Classical error correction codes, Quantum error correction codes, Three and nine qubit quantum codes. Fault tolerant quantum computation.

Text Books

1. M.A.Neilsen, I.L Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, Cambridge (2013).
2. P. Kaye, R. Laflamme and M. Mosca, "An Introduction to Quantum Computing", Oxford University Press (2006).

References

1	Chris Bernhardt, "Quantum computing for everyone", MIT press,2020.
2.	Parag K.Lala, "Quantum Computing – A Beginners's Introduction", First Edition, TMH, 2019.
3.	NPTEL course on "Introduction to Quantum Computing: Quantum Algorithms and Qiskit" by IBM and IIT Madras.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basic principles of quantum computation and quantum mechanics.
CO2	Understand the difference between classical and quantum algorithm approach and Design quantum circuits using quantum gates.
CO3	Analyse the behaviour of basic quantum algorithms.
CO4	Learn about the operators involved in Quantum computing and their applications

Stream II (Network and Security)

Course Code	CSPE11
Course Title	Cyber Physical System
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	CA and End semester Examination

Course Learning Objectives (CLO)

CO1	To develop the student's ability to understand the concept of cyber physical systems' characteristics, requirements and architecture.
CO2	To provide the students with some knowledge and analysis skills associated with the principles of memory organisation and bus structure of cyber physical systems.
CO3	To develop the student's ability to understand the concepts of cyber physical system software with special emphasis on real time operating system and particularly real time job scheduling.
CO4	To provide basic knowledge of power aware architecture & hardware software design and AI enabled Secure CPS.

Course Content:

UNIT 1 Fundamentals of Cyber Physical Systems

Motivation and examples of CPS e.g. Energy, Medical and Transportation Cyber Physical Systems - Key design drivers and quality attributes of CPS - Cyber-Physical Systems (CPS) in the real world - Basic principles of design and validation of CPS - Industry 4.0 AutoSAR - IIOT implications - Building Automation

UNIT 2 Platform Components for Cyber Physical Systems

CPS HW platforms - Processors, Sensors, Actuators - CPS Network – WirelessHart - CAN, Automotive Ethernet Scheduling Real Time CPS tasks: Table-driven and Event driven schedulers - Hybrid schedulers.

Tutorials: Truetime/Jittertime, CAN tools, WSN-CPS simulation

UNIT 3 Principles of Dynamical Systems

Dynamical Systems and Stability - Controller Design Techniques - Performance under Packet drop and Noise.

Tutorials: System modelling, Control design and stability using Z3 solver

UNIT 4 CPS Implementation Issues

From features to automotive software components - Mapping software components to ECUs - CPS Performance Analysis: Effect of scheduling, bus latency, sense and actuation faults on control performance - network congestion

UNIT 5 Intelligent and Secure CPS

Safe Reinforcement Learning: Robot motion control - Autonomous Vehicle control - Gaussian Process Learning: Smart Grid Demand Response - Building Automation - Security of CPS: Motivation - Basic Techniques - Cyber Security Requirements - Attack Model - Attack detection and mitigation in CPS – Countermeasures.

Tutorials: Use of OpenAI-gym, Carla, Matlab for safe-RL/MPC based autonomous driving, Ventos/SUMO for Cooperative driving, Matlab for power system loop modelling

Text Books:

1. R. Rajkumar, D. de. Niz and M. Klein, “Cyber Physical Systems”, Addision-Wesely, 2017.
2. Suh, Sang C., U. John Tanik, John N. Carbone, and Abdullah Eroglu, eds. “Applied cyber-physical systems”. Springer New York, 2014.
3. Alur, Rajeev. “Principles of cyber-physical systems”. MIT Press, 2015.
4. Colombo, Armando W., Thomas Bangemann, Statmatis Karnouskos, Jerker Delsing, Petr Stluka, Robert Harrison, Francois Jammes, and Jose L. Lastra. "Industrial cloud-based cyber-physical systems." The Imc-aesop Approach 22 (2014): 4-5.

Reference Books:

1.	Andrew M Sloss, Dominic Symes, Chris Wright, “ARM System Developers Guide: Designing optimizing System Software” (Online resource)
2.	https://ptolemy.berkeley.edu/projects/cps/

Course Outcomes (CO)

At the end of the course student will be able to

CO1	To gain knowledge on the computer architectural design principles and performance enhancement strategies and distributed systems.
CO2	To Solve the performance related problems of real time operating system.
CO3	To analyze the performance of embedded processing, memory, bus efficiencies, real time Operating System performance h/w s/w codesign.
CO4	To understand and develop Secure and Safe AI enabled CPS for real world applications in Industry 5.0

Course Code	CSPE22
Course Title	Internetworking Protocols
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment and End semester examination

Course Learning Objectives (CLO)

CO1	To provide insight about networks, topologies, and the key concepts
CO2	To gain comprehensive knowledge about the layered communication architectures (OSI and TCP/IP) and its functionalities
CO3	To understand the principles, key protocols, design issues, and significance of each layers in ISO and TCP/IP
CO4	To know the implementation of various layers

Course Contents

UNIT I Network Topology

Review of Reference Models - Topology and switching - IEEE Standard 802 from Ethernet - Token Bus - Token Ring and Wireless LAN - Connecting Devices.

UNIT II Introduction to IPV4

IPv4 headers - IP forwarding - Host Processing of IP datagrams - DHCP and Auto-configuration - Firewalls and NAT - ICMPv4 - IP Fragmentation - DNS - Broadcasting and Local Multicasting - IGMP - Routing Protocols.

UNIT III IPV6

IPv6 Transition issues - Protocol basics - Addressing - Options and Extension headers - ICMPv6 - Neighbor Discovery - Routing - Autoconfiguration - Multicast Listener Discovery (MLD) - IPv6 and DNS.

UNIT IV Transmission Control Protocol

Transmission Control Protocol (TCP) - TCP Connection Management - TCP Data Flow and Window Management - Stream Control Transmission Protocol (SCTP) - Services - SCTP Association management - SCTP flow and error control.

UNIT V Overview of Mobile IP

Need for Mobile IP - Overview of Mobile IP - Details of Mobile IP - Tunneling - Mobility for IPv6 - Applications of Mobile IP – Security primer - Campus Mobility - Internet wide mobility - A service provider perspective.

Text Books

1. W. Richard Stevens, G. Gabrani, “TCP/IP Illustrated: The Protocols”, Pearson, 2011.
2. Peter Loshin, Morgan Kaufmann, “IPv6: Theory, Protocol, and Practice”, Second Edition, 2003.

Reference Books:

1.	James Solomon, "Mobile IP: The Internet Unplugged", First Edition, Pearson Education, 2008.
2.	Kevin R. Fall, W. Richard Stevens, "TCP/IP Illustrated, Vol. 1 - The Protocols", Second Edition, Addison-Wesley, 2012.
3.	Silvia Hagen, "IPv6 Essentials", Second Edition, O'Reilly Media, 2006.
4.	Charles E. Perkins, "Mobile IP: Design Principles and Practices", First Edition, Pearson Education, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Gain insight about basic network theory and layered communication architectures
CO2	Configure and troubleshoot basic IPv4 network settings, such as IP addresses, subnet masks, default gateways, and DNS servers
CO3	Familiarize about the basics of IP addressing, subnetting, and routing in IPv6 networks
CO4	Code and implement different types of transport layer protocols such as UDP, TCP and SCTP

Course Code	CSPE23
Course Title	Network Security
Type of Course	PE
Pre-requisites	CSPC63
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the network security, services, attacks, mechanisms, types of attacks
CLO2	To comprehend and apply authentication services
CLO3	To apply authentication algorithms
CLO4	To comprehend and apply network layer security protocols, Transport layer security protocols, Web security protocols

Course Contents

UNIT I Overview of Network

Overview of Network Security - Security services - attacks - Security Issues in TCP/IP suite - Sniffing - spoofing - buffer overflow - ARP poisoning - ICMP Exploits - IP address spoofing - IP fragment attack - routing exploits - UDP exploits - TCP exploits. *

UNIT II Message Authentication Code

Authentication requirements - Authentication functions - Message Authentication Codes - Hash Functions - Security of Hash Functions and MACs - MD5 message Digest algorithm - Secure Hash Algorithm - RIPEMD - HMAC Digital Signatures - Authentication protocols - Kerberos - X.509.*

UNIT III IP Security

IP Security - AH and ESP - SSL/TLS - SSH - Web Security - HTTPS - DNS Security - Electronic Mail Security (PGP - S/MIME). *

UNIT IV Viruses

Intruders - Viruses - Worms - Trojan horses - Distributed Denial-Of-Service (DDoS) - Firewalls - IDS - Honey nets - Honey pots. *

UNIT V Introduction to Wireless Network Security

Introduction to wireless network security - Risks and Threats of Wireless networks - Wireless LAN Security (WEP - WPA). *

*Programming assignments are mandatory.

Text Books

1. W. Stallings, “Cryptography and Network Security: Principles and Practice”, Fifth Edition, Prentice Hall, 2013.

2. Yang Xiao, Yi Pan, “Security in Distributed and Networking Systems”, World Scientific, 2007.

Reference Books

1.	Aaron E. Earle, "Wireless Security Handbook", Auerbach Publications, Taylor & Francis Group, 2006.
2.	Atul Kahate, "Cryptography and Network Security", Fourth Edition,Tata McGraw Hill, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Determine appropriate mechanisms for protecting the network
CO2	Understand the security protocols and challenges
CO3	Design and develop security solutions for a given application or system
CO4	Apply Authentication algorithms for Security

Course Code	CSPE24
Course Title	Wireless Network Systems
Type of Course	PE
Prerequisites	CSPC53
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment & End Semester Examination

Course Learning Objectives (CLO)

CO1	To understand the fundamental principles and trends in wireless communication systems and cellular technologies.
CO2	To gain knowledge of Wireless Wide Area Networks (WAN) and the evolution of cellular technologies from the first generation to third-generation systems.
CO3	To learn the architecture, services, and standards of Wireless Local Area Networks (WLAN).
CO4	To explore the characteristics, protocols, and standards of AdHoc and sensor networks, as well as Wireless MAN and PAN.

Course Content:

UNIT I Wireless Communications & Cellular System Fundamentals
Introduction to wireless communications systems - examples - comparisons and trends - Cellular systems - Frequency Management and Channel Assignment - types of handoffs and their characteristics - dropped call rates & their evaluation - MAC techniques for Wireless Communication: FDMA - TDMA - MA (FHMA/ CDMA/ Hybrid techniques) - SDMA techniques. *

UNIT II Wireless WAN
Wireless WAN: First Generation Analog - Second Generation TDMA - GSM - Short Messaging Service in GSM - Second Generation CDMA–IS-95 - GPRS - Third Generation Systems (WCDMA/CDMA2000). *

UNIT III Wireless LAN Architecture
Wireless LAN: Introduction to wireless LANs - IEEE 802.11 WLAN - Architecture and Services - Physical Layer - MAC sub layer - MAC Management Sub layer - Other IEEE 802.11 standards -HIPERLAN -WiMAX standard. *

UNIT IV AdHoc Networks
Ad hoc and Sensor Networks: Characteristics of MANETs - Table-driven and Source-initiated On Demand routing protocols - Hybrid protocols - Wireless Sensor networks - Classification - MAC and Routing protocols. *

UNIT V MAC Layer
Wireless MAN and PAN: Wireless MANs - Physical and MAC layer details - Wireless PANs - Architecture of Bluetooth Systems - Physical and MAC layer details - Standards. *
*Programming assignments are mandatory.

Text Books:

1. William Stallings, “Wireless Communications and Networks”, Second Edition, Pearson/Prentice Hall of India, 2007.
2. Dr. Monica Bhutani, Dr. Monica Gupta, Dr. Kirti Gupta, Dr. Nitish Pathak, “Wireless Communication Networks and Applications”, 2024.
3. Dharma Prakash Agrawal, Qing-An Zeng, “Introduction to Wireless and Mobile Systems”, Second Edition, Thomson India Edition, 2007.

Reference Books:

1.	Andrea Goldsmith, "Wireless Communications", Second Edition, Cambridge University Press, 2020.
2.	Ivan B. Djordjevic, "Advanced Optical and Wireless Communications Systems", Springer, 2022. ISBN: 978-3030984908.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Make a critical assessment of wireless networks, including cellular systems, MAC techniques, and frequency management.
CO2	Comprehend the fundamentals of Wireless WAN and their evolution, including GSM, CDMA, and third-generation systems.
CO3	Analyse the architecture, services, and standards of Wireless LANs, including IEEE 802.11, HIPERLAN, and WiMAX
CO4	Apply the knowledge gained in the development of MAC and network layer protocols for AdHoc networks and Wireless MAN/PAN.

Course Code	CSPE25
Course Title	Advanced Cryptography
Type of Course	PE
Prerequisites	CSPC63
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the concepts of applied cryptography
CLO2	To understand the application of cryptographic techniques in real world applications
CLO3	To comprehend the notion of provable security and its implication with improved security guarantees
CLO4	To introduce the concept of block chain technology

Course Content

UNIT I

Review of number theory - group - ring and finite fields - quadratic residues - Legendre symbol - Jacobi symbol - Probability - Probability - Discrete random variable - Continuous random variable - Markov's inequality - Chebyshev's inequality - normal distribution - the geometric and binomial distributions. *

UNIT II

Symmetric cryptosystem - Stream cipher - Cryptanalysis: Cube attack - Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA) - Chosen Cipher text Attacks (IND-CCA1 and IND-CCA2) - Attacks under Message Non-malleability: NM-CPA and NM-CCA2 - Inter-relations among the attack model. *

UNIT III

Public key cryptography - RSA cryptosystem - probabilistic encryption - homomorphic encryption - Elliptic curve cryptosystems - Digital signatures and the notion of existential unforgeability under chosen message attacks - El Gamal digital signature scheme - Schnorr signature scheme - blind signature. *

UNIT IV

Zero Knowledge Proofs and Protocols - Multi party computation: Models and definitions of Secure Computation - Secret Sharing Schemes - Oblivious Transfers (OT) and Extensions - Circuit Garbling. *

UNIT V

Blockchain technology - Consensus algorithm - Incentives and proof of work - Smart contract - Bitcoin. *

*Programming assignments are mandatory.

Text Books

1. W. Mao, "Modern Cryptography: Theory & Practice", Pearson Education, 2004.
2. Thomas Koshy, "Elementary Number Theory with Applications", Elsevier India, 2005.

References

1.	Menezes A et al., "Handbook of Applied Cryptography", CRC Press, 1996.
2.	Koblitz N., "Course on Number Theory and Cryptography", Springer Verlag, 1986
3.	Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman, **"**An Introduction to Mathematical Cryptography", Springer Publication

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concepts of Blockchain Technology, Zero knowledge Proof and Multi party Computation
CO2	Break cryptosystems that are not provably secure
CO3	Derive simple provable security proofs for cryptographic schemes
CO4	Design and implement cryptographic protocols and use cryptographic algorithms in security

Course Code	CSPE26
Course Title	Information Security
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basics of Information Security
CLO2	To know the legal, ethical and professional issues in Information Security
CLO3	To know the aspects of risk management
CLO4	To become aware of various standards in this area
CLO5	To know the technological aspects of Information Security

Course Content

UNIT I Introduction

History - What is Information Security? - Critical Characteristics of Information - NSTISSC Security Model - Components of an Information System - Securing the Components - Balancing Security and Access - The SDLC - The Security SDLC.

UNIT II Security Investigation

Need for Security - Business Needs - Threats - Attacks - Legal - Ethical and Professional Issues - An Overview of Computer Security - Access Control Matrix - Policy - Security policies - Confidentiality policies - Integrity policies and Hybrid policies.

UNIT III Security Analysis

Risk Management - Identifying and Assessing Risk - Assessing and Controlling Risk - Systems: Access Control Mechanisms - Information Flow and Confinement Problem.

UNIT IV Logical Design

Blueprint for Security - Information Security Policy - Standards and Practices - ISO 17799/BS 7799 - NIST Models - VISA - International Security Model - Design of Security Architecture - Planning for Continuity.

UNIT V Physical Design

Security Technology - IDS - Scanning and Analysis Tools - Cryptography - Access Control Devices - Physical Security - Security and Personnel.

Text Book

1. Michael E Whitman, Herbert J Mattord, “Principles of Information Security”, Vikas Publishing House, New Delhi, 2003.

References

1.	Micki Krause, Harold F. Tipton, "Handbook of Information Security Management", Vol. 1-3, CRC Press LLC, 2004.
2.	Stuart McClure, Joel Scrambray, George Kurtz, "Hacking Exposed", Tata McGraw Hill, 2003.
3.	Matt Bishop, "Computer Security Art and Science", Pearson/PHI, 2002.

Course Outcomes (CO)

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

CO1	Illustrate the legal, ethical and professional issues in information security
CO2	Demonstrate the aspects of risk management
CO3	Become aware of various standards in the Information Security System
CO4	Design and implementation of Security Techniques

Course Code	CSPE27
Course Title	Metaverse and Blockchain
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment & End semester examination

Course Learning Objectives (CLO)

CLO1	To understand the History of Metaverse.
CLO2	Explore the role of Metaverse to connect the real world and blockchain.
CLO3	To understand the advanced development of blockchain in the future.
CLO4	To study an open ecosystem of smart properties and assets.
CLO5	To explore the integration of futuristic technologies such as blockchain, crypto currency, DAO, AR/VR

Course Content:

UNIT I INTRODUCTION TO METAVERSE

Introduction to Metaverse and immersive experience- History of Metaverse- Metaverse value chain with 7 layer

UNIT II TECHNOLOGIES INVOLVED IN THE METAVERSE

Metaverse as a product of Extended Reality- Augmented Reality (AR)- Virtual Reality (VR)-Benefits of AR/VR-Difference between AR/ VR - Mixed Reality (MR)-Artificial Intelligence (AI) Introduction in Metaverse-Financial and Economics of Metaverse-Benefits of Metaverse

UNIT III BLOCKCHAIN ADOPTION IN METAVERSE

Blockchain Overview-History of Blockchain-Need of Decentralization in MV-Smart Contract Capabilities in Blockchain - Blockchain in Metaverse -Understanding Tokens-Understanding the NFT-NFT Token Standards-NFTs in MV-Cryptocurrency in MV

UNIT IV AR, VR, MR, BLOCKCHAIN IN METAVERSE

Everything about VR (Virtual Reality)-Everything about AR (Augmented Reality)-Everything about MR (Mixed Reality)-Blockchain Identity Management in Metaverse -NFT (non-fungible token) for Metaverse-Introduction to NFTs-History of NFTs-Benefits of NFTs

UNIT V USE-CASES

Gaming in Metaverse-Meetings in Metaverse-Virtual Learning in Metaverse-Social Interactions in Metaverse-Virtual Real-estate in Metaverse-E-commerce in Metaverse-Travel in Metaverse-Personalized Avatars-Digital Identity in Metaverse

Text Books:

1. Matthew Ball, "The Metaverse: And How It Will Revolutionize Everything" Publisher: Liveright, Kindle Edition, 2022

2. QuHarrison Terry, Scott Keeney, "The Metaverse Handbook: Innovating for the Internet's Next Tectonic Shift, Publisher: Wiley; 1st edition, 2022

Reference Books:

1.	The Wearable Technology Handbook, Haider Raad,scholar publcialtions,2017
2.	Metaverse Made Easy: A Beginner's Guide to the Metaverse, Dr.Liew Voon Kiong,Publisher, Liew Voon Kiong, 2022
3.	Metaverse For Beginners and Advanced: A Complete Journey Into the Metaverse Virtual World (Web 3.0), Darell Freeman,Publisher Darell Freeman,2022
4.	Metaverse Glossary - Your Gateway to the Future, Ravindra Dastikop, Evincepub Publishing,2022
5.	The Metaverse: Prepare Now for the Next Big Thing Paperback, Terry Winters, Winters media Publiaction 2021

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the History of Metaverse and the role of Metaverse to connect the real world and blockchain.
CO2	Working with advanced development of blockchain in the future.
CO3	Exploring the open ecosystem of smart properties and assets.
CO4	Integrating futuristic technologies such as blockchain, cryptocurrency, DAO, AR/VR

Stream III (AI and Applications)

Course Code	CSPE31
Course Title	Image Processing and Applications
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the fundamentals of image processing and various transformations applied in an image
CLO2	To learn image enhancement techniques
CLO3	To understand image restoration
CLO4	To impart knowledge on different compression techniques
CLO5	To discuss on image segmentation and feature representations

Course Content

UNIT I Introduction

Introduction to Digital Image Processing - Characteristics of Digital Image - Basic relationship between pixels - Image sampling and quantization - Color models - Basic Geometric Transformations - Fourier Transform - Cosine-Sine and Hartley Transform - Hadamard-Haar-Slant Transform - Discrete Fourier Transform.

UNIT II Image Enhancement Techniques

Spatial Domain Methods - Basic Grey Level Transformation - Histogram Processing - Image subtraction - Image averaging - Spatial filtering - Smoothing - Sharpening filters - Laplacian filters - Frequency domain filters - Smoothing - Sharpening filters - Homomorphic filtering.

UNIT III Image Restoration

Model of Image Degradation/restoration process - Noise models - Spatial and Frequency Filters - Inverse filtering & Wiener Filtering - Least mean square filtering - Constrained least mean square filtering.

UNIT IV Image Compression Fundamentals

Image Compression Models - Lossless compression: Variable length coding - LZW coding - Bit plane coding - predictive coding - DPCM - Lossy Compression: Lossy Predictive Coding - Transform coding - Wavelet coding.

UNIT V Image Segmentation & Analysis

Image Segmentation techniques - Edge detection - Thresholding - Region - Boundary Extraction & Representation - Region - Moment representation - chain codes - Polygonal approximation - Texture - Pattern Recognition.

Applications - Fingerprint/iris recognition - Remote sensing - Automatic character recognition - Medical image processing.

Text Book

1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", Fourth Edition, Pearson Education, 2018.
2. S Jayaraman, S Esakkirajan, T Veerakumar, **"**Digital Image Processing", Second Edition, Mc Graw Hill, 2020.

References

1	A.K. Jain, "Fundamentals of Digital Image Processing", PHI, New Delhi, 2015.
2	William K Pratt, "Digital Image Processing", Fourth Edition, John Wiley, 2007.
3	S E Umbaugh, "Digital Image Processing and Analysis: Application with MATLAB and CVIP Tools", Third Edition , Taylor & Francis, CRC Press, 2018.
4	Frank Y. Shih, "Image Processing and Pattern Recognition", Wiley – IEEE Press, 2010.

Course Outcomes (CO)

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

CO1	Differentiate and interpret various image enhancement techniques
CO2	Reconstruct the image from the degraded image
CO3	Analyze and use appropriate image compression techniques
CO4	Suggest proper image features for classification problems

Course Code	CSPE32
Course Title	Machine Learning Techniques and Practices
Type of Course	PE
Prerequisites	CSPC54
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Objective

CLO1	To learn the clustering techniques and their utilization in machine learning
CLO2	To study the neural network systems for machine learning
CLO3	To understand reinforcement and deep learning
CLO4	To learn methodology and tools to apply machine learning algorithms to real data and evaluate their performance

Course Contents

UNIT I

Introduction and mathematical preliminaries - Vectors - Inner product - Outer product - Inverse of a matrix - Eigen analysis - Singular value decomposition - Probability distributions - Conditional probability distribution and Joint probability distribution - Bayes theorem - Types of Machine Learning - Supervised Learning - Classification models - Naïve Bayes Classifier - Decision trees - Entropy computation using GINI - Information Gain - Support Vector Machines - non-linear kernels - KNN model - MLP - CART - Ensemble Methods: Bagging - Boosting - Gradient boosting.

UNIT II

Linear models for regression - Maximum Likelihood Estimation (MLS) - least squares - regularized least squares - The Bias-Variance Decomposition - Bayesian Linear Regression - Linear models for classification - Discriminant functions - Fisher's linear discriminant - Probabilistic generative models - Probabilistic discriminative models - Bayesian logistic regression - Bayesian learning - maximum a posterior (MAP) estimation.

UNIT III

Clustering - K-Means clustering - Hierarchical Clustering - Mixture of Gaussians - Expectation maximization for mixture models (EM) - Dimensionality Reduction - Principal Component Analysis (PCA) - Linear Discriminant Analysis (LDA).

UNIT IV

Graphical models - Markov random fields - Hidden Markov Models - Representation - learning - Decoding - Inference in graphical models - Monte Carlo models - Sampling.

UNIT V

Reinforcement Learning - Model based - Model Free - Q learning - Introduction to Deep learning.

Text Books

1. Tom Mitchell, "Machine Learning", McGraw Hill, 1997.
2. E. Alpaydin, "Introduction to Machine Learning", Second Edition, Prentice-Hall of India, 2010.

Reference Books

1	Simon Haykin, "Neural Networks and Learning Machines", Pearson, 2008.
2	Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning from Theory to Algorithms", Cambridge University Press, 2014.
3	R.O. Duda, P.E. Hart, D.G. Stork, "Pattern Classification", Second Edition, Wiley-Inderscience, 2000.
4	T. Hastie, R. Tibshirani, J. Friedman, "The Elements of Statistical Learning", Springer, 2011.

Course Outcomes

Upon completion of this course, the students will be able to:

CO1	Evaluate the use of data from acquisition through cleaning, warehousing, analytics, and visualization to the ultimate business decision
CO2	Mine data and carry out predictive modelling and analytics to support business decision-making
CO3	Suggest prescriptive modelling techniques and execute real-time analytical methods on streaming datasets to react quickly to customer needs
CO4	Apply graph analytics on data

Course Code	CSPE33
Course Title	Deep Learning Techniques
Type of Course	PE
Prerequisites	CSPC54
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To introduce building blocks of deep neural network architecture
CO2	To learn deep learning algorithms and its problem settings
CO3	To understand representation and transfer of knowledge using deep learning
CO4	To learn to use deep learning tools and framework for solving real-life problems
CO5	To use Python for Deep Learning

Course Content:

UNIT I Deep Networks

Deep Feedforward Networks - Learning XOR - Gradient Based learning - Hidden Units - Back-propagation and other Differential Algorithms - Regularization for Deep Learning - Optimization for training Deep Models.

UNIT II Convolutional Networks

Convolution operation - Motivation - Pooling - Convolution and Pooling as strong prior - Efficient convolution algorithms - Unsupervised features - Sequence Modeling: Recurrent and Recursive Nets - LSTM Networks - Applications - Computer Vision - Speech Recognition - Natural Language Processing.

UNIT III Linear factor Models

Probabilistic PCA and Factor Analysis - Independent Component Analysis (ICA) - Auto encoders - Regularized Auto encoders - Representational Power - Layer size and Depth - Stochastic Auto encoders - Applications.

UNIT IV Representation Learning

Greedy Layer-wise Unsupervised Pre-Training - Transfer learning and Domain Adaptation - Deep Generative Models.

UNIT V Deep Learning with Python

Introduction to Keras and Tensorflow - Deep Learning for computer vision - convnets - Deep Learning for Text and Sequences - Generative Deep Learning - Text Generation with LSTM - DeepDream - Neural Style Transfer - Generating images with variational autoencoders - Generative Adversarial Networks (GAN).

Text Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, The MIT Press, 2016.

2. N. Buduma, N. Buduma and J Papa, “Fundamentals of deep learning”, O'Reilly Media, Inc,2022.

Reference Books:

1.	Francois Chollet, "Deep Learning with Python", Manning Publications, 2017.
2.	Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", First Edition, O'Reilly Media, 2017.
3.	J. Patterson, and A. Gibson, "Deep learning: A practitioner's approach", O'Reilly Media, Inc, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains
CO2	Incorporate transfer of knowledge in machine learning algorithms
CO3	Implement deep learning algorithms and solve real-world problems
CO4	Develop Deep Learning techniques using Python

Course Code	CSPE34
Course Title	Natural Language Processing
Type of Course	PE
Prerequisites	CSPC62
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To understand the steps involved in Natural language processing
CO2	To learn about the lexical, syntactic and semantic analysis of natural language processing
CO3	To explore the various parsing techniques for natural languages
CO4	To understand the statistical models for Natural language processing and to learn about the various applications involved in Natural language processing

Course Content:

UNIT I Lexical Analysis

Lexical Analysis - Regular expression and Automata for string matching - Words and Word Forms - Morphology fundamentals - Morphological Diversity of Indian Languages - Morphology Paradigms - Finite State Machine / Transducers Based Morphology - Automatic Morphology Learning - Parts of Speech - N-gram Models - Hidden Markov Models.*****

UNIT II Speech Processing

Biology of Speech Processing - Place and Manner of Articulation - Word Boundary Detection - Argmax based computations - HMM and Speech Recognition - Text to Speech Synthesis - Rule Based-Concatenative based approach. *

UNIT III Parsing

Theories of Parsing - Parsing Algorithms – Earley Parser - CYK Parser - Probabilistic Parsing - CYK - Resolving attachment and structural ambiguity - Shallow Parsing - Dependency Parsing - Named Entity Recognition - Maximum Entropy Models - Conditional Random Fields. *

UNIT IV Lexical Knowledge Networks

Meaning: Lexical Knowledge Networks - Wordnet Theory - Indian Language Wordnets and Multilingual Dictionaries - Semantic Roles - Word Sense Disambiguation - WSD and Multilingualism - Metaphors - Coreference and Anaphora Resolution. *

UNIT V Applications

Applications: Sentiment Analysis - Text Entailment - Machine Translation - Question Answering System - Information Retrieval - Information Extraction - Cross Lingual Information Retrieval (CLIR). *

*Programming Assignments are mandatory

Text Books:

1. Jurafsky Daniel, Martin James, “Speech and Language Processing”, Second Edition, Tenth Impression, Pearson Education, 2018.

2. Christopher Manning, Schutze Heinrich, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.

Reference Books:

1.	Allen James, "Natural Language Understanding", Second Edition, Benjamin Cumming, 1995.
2.	Charniack Eugene, "Statistical Language Learning", MIT Press, 1993.
3.	Foundations of Statistical Natural Language Processing, The MIT Press Cambridge, Massachusetts London, England,1999.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Suggest appropriate lexical and parsing techniques for a given natural language
CO2	Apply appropriate statistical models for a given natural language application
CO3	Modify existing algorithms to suit any natural language for processing
CO4	Suggest appropriate pre-processing steps essential for the various applications involving natural language processing

Course Code	CSPE35
Course Title	Deep Learning Paradigms for Computer Vision
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Cycle tests, Programming and Mathematical Assignments, End Semester

Course Learning Objectives (CLO)

CLO1	To understand the basic ideas, principles and motion analysis techniques of Computer Vision.
CLO2	To understand the motion analysis Techniques in Computer Vision.
CLO3	To understand and implement Deep Learning Architectures
CLO4	To understand Deep Learning Models for Computer Vision
CLO5	To understand the methods of solving real life problems with respect to computer Vision using Deep Learning techniques

Course Content:

UNIT I BASICS OF COMPUTER VISION

Introduction-Image Formation-Image Representation-Linear Filtering-Image in frequency domain Image Sampling-Edge Detection-Feature detection - SIFT and its variants- Image Segmentation-Feature matching.

UNIT II MOTION ANALYSIS

Background Subtraction and Modeling-Optical Flow- KLT- Spatio-Temporal Analysis-Dynamic Stereo- Motion parameter estimation

UNIT III DEEP LEARNING ARCHITECTURES

CNN Architectures – Convolution – Pooling Layers – Back propagation in CNN-Transfer Learning -RNN, LSTM, GRU, Encoder/Decoder Architectures – Autoencoders –Variational Autoencoders – Adversarial Generative Networks – Self Attention Mechanism.

UNIT IV DEEP LEARNING MODELS FOR COMPUTER VISION

Object Classification-VGGNET, RESNET, ALEXNET, DENSENET, EFFICIENT NET, MOBILENET, INCEPTION V3, Object Detection-R-CNN, F-RCN, SSD, Retinanet, YOLO, CornerNet, Image Segmentation- U-Net, SegNet, Mask-RCNN, Attention Models-Transformers

UNIT V APPLICATIONS AND RECENT TRENDS IN COMPUTER VISION

Applications- Image Editing, Inpainting, Superresolution, 3D Object Generation, Security, Surveillance-Object Tracking-Automatic Image Captioning. Recent Trends- Zero-shot, One-shot, Few-shot Learning-Self-supervised Learning and Reinforcement Learning in Vision

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, 2016.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, 2010.
3. Simon Prince, Computer Vision: Models, Learning, and Inference, 2012.
4. Andrew Glassner, Deep Learning: A Visual Approach, No Starch Press, 2021.

Reference Books:

1.	Mahamoud Hassaballah, Deep Learning in Computer Vision Principles and Applications, CRC Press, 2021
2.	Seth Weidman, Deep Learning from Scratch, Building with Python, Oreilly, 2019.
3.	Yoshua Bengio, Learning Deep Architectures for AI, 2009.
4	Michael Nielsen, Neural Networks and Deep Learning, 2016.
5	David Forsyth, Jean Ponce, Computer Vision: A Modern Approach, 2002.
6	Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Implement fundamental image processing techniques required for computer vision
CO2	Employee the motion analysis techniques for solving real life problem
CO3	Apply the deep learning architectures to various problems
CO4	Develop applications of computer vision using deep learning techniques

Course Code	CSPE36
Course Title	Responsible & Ethical AI
Type of Course	PE
Prerequisites	CSPC54
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To experience an awareness on the responsible and ethical aspects of AI
CLO2	To understand the metrics and principles of responsible AI
CLO3	To explore the various areas that need to be checked for ethical aspects of AI
CLO4	To know about explainability AI models
CLO5	To understand the various attacks possible with AI algorithms

Course Content:

Unit I

AI Capabilities Improvement, Imminent risks from AI Models: Toxicity, bias, goal misspecification, adversarial examples etc., Long-term risks from AI Models: Misuse, Misgeneralization, Rogue AGI, Principles of RAI - Transparency; Accountability; Safety, Robustness and Reliability; Privacy and Security; Fairness and non-discrimination; Human-Centred Values; Inclusive and Sustainable development, Interpretability – The AI Alignment Problem

Unit II

Introduction to Deep Learning Techniques, Language/Vision Models, AI Risks for Gen models, Bias in LLMs – Policing and surveillance - Adversarial Attacks – Vision, NLP – Social media and attention Engineering – autonomous weapon systems and military

Unit III

ML Poisoning Attacks like Trojans, Implications for current and future AI safety, Explainability, Taxonomy of ML Explainability Methods – Shapley Additive exPlanations (SHAP) – Working example of SHAP – LIME (Local Interpretable Model-Agnostic Explanations) – Working example of LIME - Imminent and Long-term potential for transparency techniques, Mechanistic Interpretability, Representation Engineering, model editing and probing, Critiques of Transparency for AI Safety

Unit IV

ML attacks and counter measures – Attack prevention and Monitoring - Model Drift – concept Drift - Privacy & Fairness in AI, Metrics and Tools for RAI - measuring bias/fairness, audit mechanisms and Compliance

Unit V

Data and Model Privacy – Differential Privacy – Federated learning – RAI lifecycle – RAI Canvas – Sustainability RAI in domain such as Legal, Health care, Education, Policy issues in RAI

Textbooks:

1. Virginia Dignum, "Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way" Springer Nature, 04-Nov-2019;ISBN-10 : 3030303705, ISBN-13 : 978-3030303709
2. Adnan Masood, Heather Dawe, Ed Price, "Responsible AI in the Enterprise: Practical AI Risk Management for explainable, auditable and safe models with hyperscalers and Azure OpenAI", Pack Publishing, 2023

Reference Books:

1.	Christoph Molnar "Interpretable Machine Learning".Lulu, 1st edition, March 24, 2019; eBook. ISBN-10 : 0244768528, ISBN-13 : 978-0244768522 [available online]
2.	Patrick Hall, James Curtis, Parul Pandey, "Machine learning for High-Risk Applications", O'Reilly Media, 2023
3.	Beena Ammanath, "Trustworthy AI", Wiley, 2022
4	Sray Agarwal, Shashin Mishra, "Responsible AI" Implementing Ethical and Unbiased algorithms", Springer, 2021

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design AI applications incorporating ethical aspects of AI
CO2	Suggest appropriate levels of transparency and security requirement for AI applications
CO3	Modify existing metrics as well as define new metrics for measuring the responsibility level of applications involving AI
CO4	Design AI applications incorporating privacy and security aspects

Course Code	CSPE37
Course Title	Generative AI
Type of Course	PE
Prerequisites	CSPC54
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To understand the basic concepts of Deep Learning to apply in Generative AI
CO2	To study basic application domains of Generative AI
CO3	To learn various concepts in creating Generative models and Large Language Models
CO4	To provide knowledge about creating Safe and Responsible AI systems

Course Content:

Unit I – Introduction to Deep Learning Architectures

Review on Python Programming, Jupyter Notebook and the Python Packages: Pandas, NumPy, PyTorch and Matplotlib - Review on Linear Regression and Logistic Regression as Predictive Models

Basics of Probability and Linear Algebra – Encoder-Decoder Architectures, Autoencoders, Autoregressive Models - Maximum Likelihood Learning – Types of Neural Networks, Composition of Neural Networks: From simple perceptron to multi-layer perceptron and its training, CNNs, RNNs, Transformers - Training of Neural Networks, Variational AutoEncoders (VAE)

Unit II – Prompt Engineering

Introduction to Generative AI – What is a Prompt? Elements of a Prompt. Tips for Designing Prompt, Example prompts for various use cases - Generative Texts: Introduction to AI Chatbots, Working of AI Chatbots, Popular AI Chatbots, ChatGPT and its working, Use cases of ChatGPT.

Generative Images: Role of AI in Image Generation, Image Sourcing vs Image Generation, Midjourney for Image Generation, Working of Midjourney, Advantages and disadvantages of Midjourney, Use cases of Midjourney

Generative Videos: AI Tools in Video Making, Working of AI Video Makers, Benefits of AI Video Makers, Popular AI Video Makers. Introduction, Features, Pros and Cons of Synthesia - Use case studies of Synthesia.

Tools: ChatGPT, Midjourney, Synthesia, Stable-Diffusion & Dall-E

Unit III - Generative Codes

Role of AI Tools in Programming, Copilot by Github, Working, Compatibility, Pros and Cons of Copilot. Installing the GitHub Copilot Extension, Converting Comments to Code using Copilot, Auto filling Repetitive code using Copilot, Running tests using Copilot, Navigating unfamiliar territory with Copilot, Creating an Application Entirely with Copilot.

ChatGPT Alternatives: Alternative Chatbots, Comparison of ChatGPT, Bard, LLAMA, Claude

OpenAI APIs: Understanding OpenAI APIs, OpenAI playground, Creating API keys, Authentication, Making requests

Tools: Bard and LLAMA

Unit IV – Transformers and Large Language Model (LLM)

Development of ChatBots, Building ChatBots, Integration with OpenAI API keys, Detailed description of Transformer architecture, Use cases and various models for Natural Language Processing, Training LLMs for NLP, Training, fine tuning, Evaluation and feedback through Reinforcement Learning

Generative Adversarial Networks (GAN) for Image Generation - Detailed description of GAN architecture and its training and variants LangChain: Simplifying Development with Language Models.
Tools: Open AI APIs, Botsonic, Chatbase, OLlama

Unit V –Responsible and Safe AI (RAI)
Why Responsible and Safe AI? Ethical Issues and Limitations of AI, Imminent AI risks from AI Models: Toxicity, Bias and Stereotypes in LLMs, Goal misspecification, DeepFakes, Data Poisoning, and adversarial examples etc., Dataset: SeeGULL dataset
Solution Paradigms for AI Risks, Machine (Un)learning, Addressing bias and fairness in Generative AI systems
Introduction to AI Safety, Ethics, and Society. Bio-war, Cyberweapons, RAI in Legal domain, RAI in Health care domain and RAI in Education domain

Suggested Projects/Case Study:
Build a web application with the help of generative AI tools replicating the core functionalities of any website with a great UI experience.
Generative AI with Custom Data set.
Build a chatbot to converse about a city with details about how to reach, places to visit and stay etc.
Complete one chatbot building project from various available projects in domains like Travel, E-Commerce. Finance, Healthcare, Education and Legal, etc.

Text Books
1. David Foster, Generative Deep Learning Teaching Machines to Paint, Write, Compose, and Play, (2019), O'Reilly Media.
2. Josh Kalin, Generative Adversarial Networks Cookbook, 2019, Packt Publishing.
3. Understanding Large Language Models: Foundations and Safety, https://rdi.berkeley.edu/understanding_llms/s24

Reference Books

1.	4. Bengio, Y., Goodfellow, I. and Courville, A., 2017. Deep learning (Vol. 1). Cambridge, MA, USA: MIT press.
2.	5. OpenAI, ChatGPT, Bard, Llama
3.	6. Tutorial on Generative Adversarial Networks. (https://sites.google.com/view/cvpr2018tutorialongans/) Computer Vision and Pattern Recognition, June 2018.
4.	7. Responsible and Safe AI Systems: https://onlinecourses.nptel.ac.in/noc24_cs132/preview

Course Outcomes (CO)
At the end of the course student will be able to

CO1	To design and develop fundamental Deep Learning and Generative AI based models
CO2	To gain knowledge in developing prompts for generating Images, Videos and Codes in various domains
CO3	To apply the Generative AI models to develop real world applications
CO4	To design and develop Safe and Responsible AI systems

Course Code	CSPE38
Course Title	Cognitive Science
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To know concepts, approaches and issues in the field of cognitive science and to increase the awareness of the students to the questions raised in the disciplines of computer science, linguistics, philosophy and psychology
CO2	To focus on the interaction of these disciplines in approaching the study of the mind
CO3	To make specialization on topics central to cognitive science such as the nature of mental representation, reasoning, perception, language use
CO4	To learn other cognitive processes of humans and other intelligent systems.

Course Content:

UNIT - I Introduction

Introduction to the study of cognitive sciences. A brief history of cognitive science. Methodological concerns in philosophy, artificial intelligence and psychology. Structure and constituents of the brain; Brief history of neuroscience; Mathematical models; Looking at brain signals; Processing of sensory information in the brain.

UNIT – II Neural Network Models

Neural Network Models; Processing of sensory information in the brain; motor and sensory areas; Brain Imaging, fMRI, MEG, PET, EEG; Multisensory integration in cortex; information fusion; from sensation to cognition, cybernetics; From physics to meaning; Analog vs. Digital: Code duality

UNIT - III Linguistic Knowledge

What is language?; Linguistic knowledge: Syntax, semantics, (and pragmatics); Generative linguistics; Brain and language; Language disorders; Lateralization; The great past tense debate; Cognitivist and emergent standpoints ; A robotic perspective.

UNIT - IV Robotics

Affordances, direct perception, Ecological Psychology, affordance learning in robotics; Development, child and robotic development; Attention and related concepts; Human visual attention; Computational models of attention; Applications of computational models of attentional

UNIT - V Machine Learning

Categories and concepts; Concept learning; Logic; Machine learning; Constructing memories; Explicit vs. implicit memory; Information processing (three-boxes) model of memory; Sensory memory; Short term memory; Long term memory; Rationality; Bounded rationality; Prospect theory; Heuristics and biases; Reasoning in computers; Key points in social cognition; Context and social judgment; Schemas; Social signals.

Text Books:

1. Gardner, Howard E. The mind's new science: A history of the cognitive revolution. 2nd Edition.
2. Bermúdez, José Luis. Cognitive science: An introduction to the science of the mind. Cambridge University Press, 2014.

Reference Books:

1.	McCulloch, Warren S., and Walter Pitts. "A logical calculus of the ideas immanent in nervous activity." The bulletin of mathematical biophysics 5.4 (1943): 115-133.
2.	Imaging: Brain Mapping Methods, John C. Mazziotta, Richard S. J. Frackowiak, Elsevier Science Publication.
3.	Fromkin, Rodman, and Hyams. An Introduction to Language, Boston, MA: Thomson Wadsworth, 9th edition, 2011

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Map the concepts of Psychology, Nervous system and brain and sensory motor information attributes to real world problems involving AI
CO2	Analyze the Roots of Cognitive Science
CO3	Exploit Language and Embodiment features
CO4	Explore the Affordances in biological and artificial systems, Cognitive Development and make Attention, Learning, Memory, Reasoning, Social Cognition aspects to solve real world problems.

Course Code	CSPE39
Course Title	Drone Technologies
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basics of drone concepts
CLO2	To learn and understand the fundaments of design, fabrication and programming of drone
CLO3	To impart the knowledge of flying and operation of the drone
CLO4	To know about the various applications of drone
CLO5	To understand the safety risks and guidelines of flying

Course Content:

Unit I Introduction & Modelling
Introduction to Drones and Basic components – Aerodynamic and Flight dynamics – Drone Design - Calculations and Assumptions – Propulsion and Energy Management – Anti-vibration and Noise reduction in UAV – Multi Copter Flight Control Models.

Unit II Perception
Introduction to Autonomous Navigation – Sensor Perception on UAV – Artificial Intelligence and Machine Learning – Localization and Mapping.

Unit III Mission Decision–Making
Obstacle detection and Avoidance – Mission Planning and Path Planning – Wireless Communication on UAV – Multi UAV Systems.

Unit IV Drone Building Activities
Drone Building Activities: Configuring and Calibrating Drone Components – Thrust stands and Motor/Propeller performance testing – ROS.

Unit IV Regulations & Applications
Regulations & Applications: Safety risks - Guidelines to fly safely- specific aviation regulation and standardisation - Drone license. Design of drones for applications such as medical and agriculture.

Text Books:
1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", John Wiley & Sons, Inc., 2021.
2. Terry Kilby and Belinda Kilby, "Make: Getting Started with Drones "Maker Media, Inc, 2016.

Reference Books:

1.	Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.
2.	Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 2001.
3.	Reg Austin "Unmanned aircraft systems UAV design, development and deployment", Wiley, 2010.
4.	Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

Course Outcomes (CO)

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

CO1	Comprehend Hardware components and software programming requirements of drones.
CO2	Know about a various type of drone technology
CO3	Select appropriate sensors and actuators for Drones
CO4	Use navigation and communication systems in UAVs.

Stream IV (Software Engineering for Web Applications)

Course Code	CSPE41
Course Title	Augmented and Virtual Reality
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To know the basic concepts of virtual reality
CLO2	To understand visual computation in computer graphics
CLO3	To understand the interaction between the system and the computer
CLO4	To know the application of VR in Digital Entertainment
CLO5	To know the basic concepts of augmented reality

Course Content

UNIT I

Introduction of Virtual Reality: Fundamental Concept and Components of Virtual Reality - Primary Features and Present Development on Virtual Reality - Multiple Models of Input and Output Interface in Virtual Reality: Input - Tracker - Sensor - Digital Glove - Movement Capture - Video-based Input - 3D Menus & 3DScanner – Output - Visual /Auditory / Haptic Devices.

UNIT II

Visual Computation in Virtual Reality: Fundamentals of Computer Graphics - Software and Hardware Technology on Stereoscopic Display - Advanced Techniques in CG: Management of Large-Scale Environments & Real Time Rendering.

UNIT III

Interactive Techniques in Virtual Reality: Body Track - Hand Gesture - 3D Manus - Object Grasp. Development Tools and Frameworks in Virtual Reality: Frameworks of Software Development Tools in VR.

UNIT IV

Application of VR in Digital Entertainment: VR Technology in Film & TV Production - VR Technology in Physical Exercises and Games - Demonstration of Digital Entertainment by VR.

UNIT V

Augmented and Mixed Reality: Taxonomy - technology and features of augmented reality - difference between AR and VR - Challenges with AR - AR systems and functionality - Augmented reality methods - visualization techniques for augmented reality - wireless displays in educational augmented reality applications - mobile projection interfaces - marker-less tracking for augmented reality - enhancing interactivity in AR environments - evaluating AR systems.

Text Book

1. Burdea, G. C., P. Coffet., "Virtual Reality Technology", Second Edition, Wiley-IEEE Press, 2003/2006.
2. Alan B. Craig, "Understanding Augmented Reality, Concepts and Applications", Morgan Kaufmann, 2013.

References

1	Alan Craig, William Sherman, Jeffrey Will, "Developing Virtual Reality Applications, Foundations of Effective Design", Morgan Kaufmann, 2009.
2	Jason Jerald, "The VR Book: Human-Centered Design for Virtual Reality", ACM Books,2015
3	Paul Mealy, "Virtual & Augmented Reality For Dummies", For dummies, 2018

Course Outcomes (CO)

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

CO1	Provide an opportunity to explore the research issues in Augmented Reality and Virtual Reality (AR & VR).
CO2	Understand fundamentals of computer graphics
CO3	Know the basic concept and framework of virtual reality and computer-human interaction
CO4	Develop simulator for real time application using AR & VR

Course Code	CSPE42
Course Title	Game Theory
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To explain and predict how individuals behave in a specific strategic situation, and therefore help improve decision making
CLO2	To explain in depth the standard equilibrium concepts in Game Theory
CLO3	To illustrate the concepts, real-world examples and case studies
CLO4	To design Repeated Games with public information
CLO5	To design static and Dynamic games with incomplete information

Course Contents

UNIT I Introduction to Game Theory

Games and solutions - Game theory and mechanism design - Examples from networks - Strategic form games - Matrix and continuous games - Iterated strict dominance - Rationalizability - Nash Equilibrium - existence and uniqueness - Mixed and correlated equilibrium – Super modular games - Potential/congestion games - Existence and Properties of Nash Equilibria.

UNIT II Extensive-Form Games

Definition - Strategies and Equilibria in Extensive Form Games - Backward Induction and Subgame Perfection and its Critiques.

UNIT III Repeated Games

Infinitely/finitely repeated games - Pareto Perfection and Renegotiation - Proofness in Repeated Games - Repeated Games with incomplete Public Information - Trigger strategies - Fork Theorem with Imperfect Public Information.

UNIT IV Static Games with incomplete information

Mixed and Behavioral strategies - Bayesian Nash equilibrium - Applications in auctions - Different auction formats - Revenue and efficiency properties of different auctions - Bayesian Games and Mechanism Design Principle - Single Agent - Several Agents - Further topics in Mechanism Design.

Unit V Dynamic Games with incomplete information

Introduction - Perfect Bayesian Equilibrium in Multi-stage games - Extensive-Form and Strategic-Form Refinements - Reputation Effects - Sequential Bargaining under Incomplete Information.

Text Book

1. Fudenberg, Drew, Jean Tirole, “Game Theory”, Cambridge, MA: MIT Press, 1991.

Reference Books

1.	Nisan, Noam, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani, "Algorithmic Game Theory", Cambridge, UK: Cambridge University Press, 2007.
2.	Fudenberg, Drew, David Levine, "Theory of Learning in Games", Cambridge, MA: MIT Press, 1998.
3.	Michael Maschler , Eilon Solan , Shmuel Zamir "Game Theory", Second Edition, Cambridge University Press ,2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify strategic situations and represent them as games
CO2	Solve simple games using various techniques
CO3	Recommend and prescribe which strategies to implement
CO4	Develop Static and Dynamic Games

Course Code	CSPE43
Course Title	Software Testing and Automation
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Summarize to learn the criteria for test cases
CLO2	Develop and design test cases
CLO3	Analyse test management and test automation techniques
CLO4	Assess test metrics and measurements
CLO5	Design and validate website testing

Course Content:

UNIT I Introduction

Testing as an Engineering Activity - Testing as a Process - Testing Maturity Model - Testing axioms - Basic definitions - Software Testing Principles - The Tester ‘s Role in a Software Development Organization - Origins of Defects - Cost of defects - Defect Classes - The Defect Repository and Test Design - Defect Examples - Developer/Tester Support of Developing a Defect Repository.

UNIT II Test Case Design Strategies

Test case Design Strategies - Using Black Box Approach to Test Case Design - Boundary Value Analysis - Equivalence Class Partitioning - State based testing - Cause-effect graphing - Compatibility testing - user documentation testing - domain testing - Random Testing - Requirements based testing - Using White Box Approach to Test design - Test Adequacy Criteria - static testing vs. structural testing - code functional testing - Coverage and Control Flow Graphs - Covering Code Logic - Paths - code complexity testing - Additional White box testing approaches - Evaluating Test Adequacy Criteria.

UNIT III Levels of Testing

The need for Levels of Testing - Unit Test - Unit Test Planning - Designing the Unit Tests - The Test Harness - Running the Unit tests and Recording results - Integration tests - Designing Integration Tests - Integration Test Planning - Scenario testing - Defect bash elimination System Testing - Acceptance testing - Performance testing - Regression Testing - Internationalization testing - Ad-hoc testing - Alpha- Beta Tests - Testing OO systems - Usability and Accessibility testing - Configuration testing - Compatibility testing - Testing the documentation - Website testing.

UNIT IV Test Management

People and organizational issues in testing - Organization structures for testing teams - testing services - Test Planning - Test Plan Components - Test Plan Attachments - Locating Test Items - test management - test process - Reporting Test Results - Introducing the test specialist - Skills needed by a test specialist - Building a Testing Group - The Structure of Testing Group - The Technical Training Program.

UNIT V Test Automation

Software test automation - skills needed for automation - scope of automation - design and architecture for automation - requirements for a test tool - challenges in automation - Test metrics and measurements – project-progress and productivity metrics.

Text Books:

1. Srinivasan Desikan, Gopalaswamy Ramesh, "Software Testing – Principles and Practices", Pearson Education, 2006

2. Ron Patton, "Software Testing", Second Edition, Sams Publishing, Pearson Education, 2007.

Reference Books:

1.	Ilene Burnstein, "Practical Software Testing", Springer International Edition, 2003.
2.	Edward Kit, "Software Testing in the Real World – Improving the Process", Pearson Education, 1995.
3.	Boris Beizer, "Software Testing Techniques", Second Edition, Van Nostrand Reinhold, New York, 1990.
4	Aditya P. Mathur, "Foundations of Software Testing Fundamental Algorithms and Techniques", Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008.
5	B. Homes, "Fundamentals of software testing", John Wiley & Sons, 2024.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design test cases suitable for a software development for different domains
CO2	Prepare test planning based on the document
CO3	Document test plans and test cases designed
CO4	Use automatic testing tools

Course Code	CSPE44
Course Title	Agile Software Development
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop an understanding on agile software development
CLO2	To learn about the principles, planning and requirement in agile software development
CLO3	To understand the testing methodologies in agile software development
CLO4	To explore the metrics and measurement in agile software development

Course Contents

UNIT I Introduction

Agile Software Development: Basics and Fundamentals of Agile Process Methods - Values of Agile - Principles of Agile - stakeholders - Challenges Lean Approach: Waste Management - Kaizen and Kanban - add process and products add value - Roles related to the lifecycle - differences between Agile and traditional plans - differences between Agile plans at different lifecycle phases - Testing plan links between testing - roles and key techniques - principles - understand as a means of assessing the initial status of a project/ How Agile helps to build quality.

UNIT II Principles

Agile and Scrum Principles: Agile Manifesto - Twelve Practices of XP - Scrum Practices - Applying Scrum - Need of scrum - working of scrum - advanced Scrum Applications - Scrum and the Organization - scrum values.

UNIT III Planning and Product Management

Agile Product Management: Communication - Planning - Estimation - Managing the Agile approach - Monitoring progress - Targeting and motivating the team - Managing business involvement - Escalating issue - Quality - Risk - Metrics and Measurements.

UNIT IV Requirements and Testing

Agile Requirements: User Stories - Backlog Management - Agile Architecture: Feature Driven Development - Agile Risk Management: Risk and Quality Assurance - Agile Tools - Agile Testing: Agile Testing Techniques - Test-Driven Development - User Acceptance Test - Agile Review: Agile Metrics and Measurements - The Agile approach to estimating and project variables.

UNIT V Measurement

Agile Measurement - Agile Control-control parameters - Agile approach to Risk - The Agile approach to Configuration Management - The Atern Principles - Atern Philosophy - Rationale for using Atern - Refactoring - Continuous integration - Automated Build Tools - Scaling Agile for large projects: Scrum of Scrums - Team collaborations - Scrum - Estimate a Scrum Project - Track Scrum Projects - Communication in Scrum Projects - Best Practices to Manage Scrum.

Text Books

1. Robert C. Martin, "Agile Software Development, Principles, Patterns, and Practices", First Edition, Pearson Education India, 2002.
2. "Succeeding with Agile: Software Development Using Scrum", Pearson, 2010.

References

1	Robert C Martin, Micah Martin, "Agile Principles, Patterns and Practices in C#", Pearson Education, 2007
2	Steve McConnell ,"More Effective Agile: A Roadmap for Software Leaders", Construx Press,2019

Course Outcomes (CO)

At the end of the course student will be able

CO1	Distinguish between agile software development and traditional software development
CO2	Design and provide the necessary measurements and metrics for agile software development problems.
CO3	Integrate best practices of traditional and agile software development and use in real-time problem solving
CO4	Estimate risk of scrum projects

Course Code	CSPE45
Course Title	Web Technology and its Applications
Type of Course	PE
Prerequisites	CSPC42
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	To understand the basics of Web Designing using HTML, DHTML, and CSS
CO2	To learn the basics about Client-side scripts and Server-side scripts
CO3	To classify web application
CO4	To create Database connectivity

Course Content:

UNIT I

HTML - Introduction - HTML Formatting - Hyper-Links - Lists - Tables - Images - Forms - Frames - Cascading Style sheets - Types - XML - Document type definition - XML Schemas - Document Object model. *

UNIT II

Introduction to Client-Side scripting - JavaScript - Control statements - Functions - Arrays - Objects - Events - Dynamic HTML with Java Script - AJAX: Ajax Client Server Architecture - XML Http Request Object - Call Back Methods. *

UNIT III

NodeJS and Express - Introduction to AngularJS and Fundamentals of ReactJS - Web servers – IIS (XAMPP - LAMPP) and Tomcat Servers - Server-Side Scripting - Java Servlets - Java Server Pages - Java Server Faces - JSF Components - Session Tracking - Cookies. *

UNIT IV

PHP - Basic Syntax - Defining variable and constant - PHP Data types - Operator and Expression - Operator Precedence - Decisions and Loop - Functions & Recursion - String Processing and Regular Expressions - Form Processing - Working with file and Directories* - Cookies.

UNIT V

Database Connectivity with MySQL - Servlets - JSP - PHP - MongoDB - NOSQL Database* - Fundamentals of jQuery and Bootstrap.

*Programming assignments are mandatory.

Text Books:

1. Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, “Internet & World Wide Web How to Program”, Fifth Edition, Deitel Series, 2012.
2. Jason Gilmore, “Beginning PHP and MySQL from Novice to Professional”, Fourth Edition, Apress Publications, 2010.
3. Brown, Ethan, “Web Development with Node and Express: Leveraging the JavaScript Stack”, O'Reilly Media, 2019.

4. Anthony, Accomazzo, Murray Nathaniel, Lerner Ari, “Fullstack React: The Complete Guide to React JS and Friends”, Fullstack.io, 2017.

5. Kozlowski, Pawel, “Mastering Web Application Development with Angular JS”, Packt Publishing Ltd., 2013.

Reference Books:

1.	Robert W. Sebesta, “Programming with World Wide Web”, Eight Edition, Pearson, 2021.
2.	David William Barron, “The World of Scripting Languages”, Wiley Publications, 2009.
3.	Dayley B., “Node.js, MongoDB, and AngularJS Web Development”, Addison-Wesley Professional, 2ed, 2018.
4.	Vainikka J., “Full-Stack Web Development using Django REST Framework and React”, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand and interpret standard web technologies
CO2	Build real world applications using client side and server-side scripting languages
CO3	Design and develop applications using web technologies
CO4	Handling web application data with databases

Course Code	CSPE46
Course Title	Brain Computer Interface and its Applications
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CO1	Understand the basic concepts of brain computer interface
CO2	Study the various signal acquisition methods
CO3	Learn about the signal processing methods used in BCI
CO4	Understand the various machine learning methods of BCI.
CO5	Learn the various applications of BCI

Course Content:

UNIT I INTRODUCTION TO BCI

Introduction - Brain structure and function, brain-computer interface Types - Synchronous and Asynchronous -Invasive BCI - Partially Invasive BCI – Non-Invasive BCI, Structure of BCI System, BCI Monitoring Hardware, BCI Techniques - EEG, ECoG, MEG, fMRI, Ethics of Brain-Computer Interfacing**.**

UNIT II SIGNAL ACQUISITION TECHNIQUES

Brain activation patterns - brainwaves, oscillatory potential and event related potential, error related potential, slow cortical potentials, movement related potentials, stimulus related potentials - visual evoked potentials – P300 and auditory evoked potentials, potentials related to cognitive tasks.

UNIT III FEATURE EXTRACTION AND ANALYSIS

Signal pre-processing – filtering techniques, artefacts reduction, frequency domain analysis, wavelet analysis, time domain analysis, spatial filtering - Principal Component Analysis (PCA), Independent Component Analysis (ICA), topographical maps.

UNIT IV MACHINE LEARNING TECHNIQUES FOR BCI

Classification techniques – binary classification, ensemble classification, multiclass classification, Classifiers - support vector machine, neural networks, Regression – trees, deep learning techniques for BCI, evaluation metrics for BCI applications.

UNIT V APPLICATIONS OF BCI

Case Studies: Medical applications - sensory restoration, motor restoration, cognitive restoration, rehabilitation, restoring communication with menus, cursors, and spellers, brain-controlled wheelchairs; non-medical applications- web browsing and navigating virtual worlds, high throughput image search lie detection and applications in law, imagined thoughts, emotion recognition.

Text Books:

1. Rajesh. P. N. Rao, “Brain-Computer Interfacing: An Introduction”, Cambridge University Press, First edition, 2013.
2. Jonathan Wolpaw, Elizabeth Winter Wolpaw, “Brain Computer Interfaces: Principles and practice”, Oxford University Press, USA, Edition 1, January 2012.

Reference Books:

1.	Ella Hassianien, A &Azar.A.T (Editors), “Brain-Computer Interfaces Current Trends and Applications”, Springer, 2015.
2.	Bernhard Graimann, Brendan Allison, GertPfurtscheller, "Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction", Springer, 2010
3.	Saeid Sanei, Jonathon A. Chambers, “EEG Signal Processing and Machine Learning”, Wiley International, 2nd Edition, 2021

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend and appreciate the significance and role of BCI in the present contemporary world.
CO2	Assign functions appropriately to the human and to the machine.
CO3	Select appropriate feature extraction and analysis methods
CO4	Use machine learning algorithms for translation.

Course Code	CSPE47
Course Title	Full Stack Development
Type of Course	PE
Prerequisites	CSPC52
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the various components of full stack development
CLO2	To learn Node.js features and applications
CLO3	To develop applications with MongoDB
CLO4	To understand the role of Angular and Express in web applications
CLO5	To develop simple web applications with React

Course Content:

UNIT I BASICS OF FULL STACK

Understanding the Basic Web Development Framework – User – Browser – Webserver – Backend Services – MVC Architecture – Understanding the different stacks –The role of Express – Angular – Node – Mongo DB – React

UNIT II NODE JS

Basics of Node JS – Installation – Working with Node packages – Using Node package manager – Creating a simple Node.js application – Using Events – Listeners –Timers – Callbacks – Handling Data I/O – Implementing HTTP services in Node.js

UNIT III MONGO DB

Understanding NoSQL and MongoDB – Building MongoDB Environment – User accounts – Access control – Administering databases – Managing collections – Connecting to MongoDB from Node.js – simple applications

UNIT IV EXPRESS AND ANGULAR

Implementing Express in Node.js – Configuring routes – Using Request and Response objects – Angular – Typescript – Angular Components – Expressions – Data binding – Built-in directives

UNIT V REACT

MERN STACK – Basic React applications – React Components – React State – Express REST. APIs – Modularization and Webpack – Routing with React Router – Server-side rendering.

Text book:

1. Brad Dayley, Brendan Dayley, Caleb Dayley, 'Node.js, MongoDB and Angular Web Development', Addison-Wesley, Second Edition, 2018

2. Vasan Subramanian, 'Pro MERN Stack, Full Stack Web App Development with Mongo, Express, React, and Node', Second Edition, Apress, 2019.

Reference Books:

1.	Chris Northwood, 'The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer', Apress; 1st edition, 2018.
2.	Kirupa Chinnathambi, 'Learning React: A Hands-On Guide to Building Web Applications Using React and Redux', Addison-Wesley Professional, 2nd edition, 2018

Course outcomes

At the end of the course student will be able

CO1	Understand the various stacks available for web application development
CO2	Use Node.js, features of Angular and Express for application development
CO3	Develop applications with MongoDB
CO4	Develop React applications

Course Code	CSPE48
Course Title	DevOps
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce DevOps terminology, definition & concepts
CLO2	To understand the different Version control tools like Git, Mercurial
CLO3	To understand the concepts of Continuous Integration/ Continuous Testing/ Continuous Deployment
CLO4	To understand Configuration management using Ansible
CLO5	Illustrate the benefits and drive the adoption of cloud-based Devops tools to solve real world problems

Course Content:

UNIT I

INTRODUCTION TO DEVOPS: Devops Essentials - Introduction to AWS, GCP, Azure - Version control systems: Git and Github.

UNIT II

COMPILE AND BUILD USING MAVEN & GRADLE: Introduction, Installation of Maven, POM files, Maven Build lifecycle, Build phases(compile build, test, package) Maven Profiles, Maven repositories(local, central, global),Maven plugins, Maven create and build Artificats, Dependency management, Installation of Gradle, Understand build using Gradle

UNIT III

CONTINUOUS INTEGRATION USING JENKINS : Install & Configure Jenkins, Jenkins Architecture Overview, Creating a Jenkins Job, Configuring a Jenkins job, Introduction to Plugins, Adding Plugins to Jenkins, Commonly used plugins (Git Plugin, Parameter Plugin, HTML Publisher, Copy Artifact and Extended choice parameters). Configuring Jenkins to work with java, Git and Maven, Creating a Jenkins Build and Jenkins workspace, Kubernetes – Cluster Architecture.

UNIT IV

CONFIGURATION MANAGEMENT USING ANSIBLE : Ansible Introduction, Installation, Ansible master/slave configuration, YAML basics, Ansible modules, Ansible Inventory files, Ansible playbooks, Ansible Roles, adhoc commands in ansible

UNIT V

BUILDING DEVOPS PIPELINES USING AZURE 6: Create Github Account, Create Repository, Create Azure Organization, Create a new pipeline, Build a sample code, Modify azure-pipelines.yaml file

Textbooks:

1. Roberto Vormittag, "A Practical Guide to Git and GitHub for Windows Users: From Beginner to Expert in Easy Step-By-Step Exercises", Second Edition, Kindle Edition, 2016.
2. Jason Cannon, "Linux for Beginners: An Introduction to the Linux Operating System and Command Line", Kindle Edition, 2014

Reference Books:

1.	Mitesh Soni,"Hands-On Azure Devops: Cicd Implementation For Mobile, Hybrid, And Web Applications Using Azure DevOps And Microsoft Azure: CICD Implementation for DevOps and Microsoft Azur" Paperback – 1 January 2020
2.	Jeff Geerling, "Ansible for DevOps: Server and configuration management for humans", First Edition, 2015
3.	. 4. David Johnson, "Ansible for DevOps: Everything You Need to Know to Use Ansible for DevOps", Second Edition, 2016.
4	Mariot Tsitoara, "Ansible 6. Beginning Git and GitHub: A Comprehensive Guide to Version Control, Project Management, and Teamwork for the New Developer", Second Edition, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand different actions performed through Version control tools like Git.
CO2	Understand to leverage Cloud-based DevOps tools using Azure DevOps
CO3	Perform Continuous Integration and Continuous Testing and Continuous Deployment using Jenkins by building and automating test cases using Maven & Gradle
CO4	Ability to do configuration management using Ansible

Stream V (Data Engineering)

Course Code	CSPE51
Course Title	Data Interpretation and Analysis
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To provide fundamental concepts in statistics and probability
CLO2	To study random variables and various distributions
CLO3	To understand parameter estimation and hypothesis testing
CLO4	To learn regression and its different types of analysis models

Course Content:

Unit -1

Descriptive statistics: Population, sample, parameter, sampling, concept of frequency, frequency tables and graphs. Summarizing numerical data: mean, median, mode, percentile, variance, standard deviation. Chebyshev inequality with proof, correlation coefficient, correlation and causation, proof of one-sided Chebyshev's inequality. **Probability**- Sample space, event, De Morgan's laws, Boole's and Bonferroni's inequalities, conditional probability, Bayes rule, false positive paradox, Birthday paradox in discrete probability.

Unit-2

Random Variables: Discrete and continuous random variables: mean, median, moments, variance. Probability mass function (pmf), cumulative distribution function (cdf) and probability density function (pdf). Discrete RVs: Bernoulli, Binomial, Geometric, Indicator. Continuous RVs, Joint distributions and conditioning. Law of the Unconscious Statistician (LOTUS). Markov's and Chebyshev's inequality. Weak law of large numbers, Gambler's fallacy, Moment generating function.

Unit-3

Special Random Variables: Bernoulli PMF, Binomial PMF, Gaussian PDF: central limit theorem, Expression for CDF and its relation to the error function, de Moivre-Laplace theorem. Derivation of PDF of mean of different random variables; Bessel's correction for standard deviation; PDF of sample mean and sample variance of a Gaussian. Chi square distribution, Uniform distribution, Poisson distribution; Exponential distribution. Multinomial PMF - generalization of the binomial, mean vector and covariance matrix for a multinomial random variable, MGF for multinomial.

Unit-4

Parameter Estimation: Concept of parameter estimation, Maximum likelihood estimation (MLE), MLE for parameters of Bernoulli, Poisson, Gaussian and uniform distributions. Least squares line fitting as an MLE problem. Concept of estimator bias, mean squared error, variance; Concept of two-sided confidence interval and one-sided confidence interval. Nonparametric density estimation. Concept of histogram as a probability density estimator; Bias, variance and MSE for a histogram estimator for a smooth density. Hypergeometric distribution: genesis, mean, variance. Concept of kernel density estimator; Bias, variance and MSE for a kernel density estimator for a smooth density.

Unit- 5

Hypothesis Testing: Significance levels, tests concerning the mean of normal population, Bernoulli population, and Poisson distribution, testing the equality of means of two normal populations, hypothesis tests for variance of a normal population. **Regression:** Least square estimators of regression parameters; Distribution of the estimators, statistical inference about regression parameters; Coefficient of determination and the sample correlation coefficient. Analysis of residuals, weighted least squares, polynomial regression, multiple linear regression, logistic regression models.

Text book:

1. Sheldon M Ross, Introduction to Probability and Statistics for Engineers and Scientists, 5th edition, Elsevier Inc 2014

Reference Books:

1. M. H. DeGroot and M. J. Schervish, Probability and Statistics, 4th edition, Addison-Wesley, 2012
2. Jay L. Devore , Probability and Statistics for Engineering and the Sciences. 9th edition, 2012
3. Larry Wasserman , All of Statistics: A Concise Course in Statistical Inference, 1st edition, Springer publication, 2004.

Course outcomes

At the end of the course student will be able

CO1	Use mathematical tools for analyzing probabilities
CO2	Applying the appropriate concepts of probability and statistics to solve real-world problems
CO3	Understand various distributions and hypothesis testing
CO4	Understand various regression models and their applications.

Course Code	CSPE52
Course Title	Advanced Database Management Systems
Type of Course	PE
Prerequisites	CSPC52
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment & End semester examination

Course Learning Objectives (CLO)

CLO1	To understand the different database models and language queries to access databases
CLO2	To understand the normalization forms in building an effective database table
CLO3	To protect the data and the database from unauthorized access and manipulation
CLO4	To understand emerging trends in databases

Course Content:

UNIT I Relational Model Issues

ER Model - Normalization - Query Processing - Query Optimization - Transaction Processing - Concurrency Control - Recovery - Database Tuning.

UNIT II Distributed Databases

Parallel Databases - Inter and Intra Query Parallelism - Distributed Database Features - Distributed Database Architecture - Fragmentation - Distributed Query Processing - Distributed Transactions Processing - Concurrency Control - Recovery - Commit Protocols. *

UNIT III Object Oriented Databases

Introduction to Object Oriented Data Bases - Approaches Modelling and Design - Persistence - Query Languages - Transaction - Concurrency - Multi Version Locks - Recovery - POSTGRES - JASMINE - GEMSTONE - ODMG Model. *

UNIT IV Emerging Systems with Current Issues

Enhanced Data Models - Client/Server Model - Data Warehousing and Data Mining - Web Databases - Mobile Databases - XML and Web Databases - Rules - Knowledge Bases - Active and Deductive Databases - Multimedia Databases - Multimedia Data Structures - Multimedia Query languages - Spatial Databases. *

UNIT V Advanced Databases

Introduction to NoSQL - Aggregate Data Models - HBase: Data Model and Implementations - HBase Clients – Examples – Cassandra: Data Model – Examples – Cassandra Clients - Hadoop Integration - Traditional Indexing Methods (Secondary Keys - Spatial Access Methods) - Text Retrieval - Multimedia Indexing - 1D Time Series - 2D Color images – Sub pattern Matching – Open Issues - Uncertainties.

*Programming assignments are mandatory.

Text Books:

1. Thomas Connolly, Carolyn Begg, “Database Systems: A Practical Approach to Design, Implementation, and Management”, Addison-Wesley, Fifth Edition, 2009.
2. R. Elmasri, S. B. Navathe, “Fundamentals of Database Systems”, Pearson/Addison Wesley, Fifth Edition, 2006.

Reference Books:

1.	Abraham Silberschatz, Henry F. Korth, S. Sudharshan, "Database System Concepts", Fifth Edition, Tata McGraw Hill, 2006.
2.	C. J. Date, A. Kannan, S. Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.
3.	P. J. Sadalage, M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
4.	Lars George, "HBase: The Definitive guide", O'Reilly Media Inc., 2011.
5.	Eben Hewitt, "Cassandra: The definitive Guide", O'Reilly Media Inc., 2010.
6.	Carlo Zaniolo, Stefano Ceri, "Advanced Database Systems", Morgan Kauffmann Publishers, 1997.
7.	Chhanda Ray, "Advanced database system", independently published, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend the complex query processing techniques
CO2	Design distributed and object-oriented databases
CO3	Design and implement multimedia databases and writing query structure
CO4	Develop skill set in file organization, Query Optimization, Transaction management, and database administration techniques

Course Code	CSPE53
Course Title	Data Analytics
Type of Course	PE
Prerequisites	CSPC52
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Cycle Test, Assignment, End Semester

Course Learning Objectives (CLO)

CLO1	To understand the basic principles of Data Analytics
CLO2	To learn the various Data Analytic methods
CLO3	To understand the various clustering algorithms and its application on data
CLO4	To work with stream data model and computing

Course Content:

UNIT I

Introduction to Data Analytics - Types of Data Analytics - Predictive Analytics - Simple linear regression - Multiple linear regression - Auto regression - Moving Average - Autoregressive Integrated Moving Average - Data Pre-processing - Data Cleaning - Data Integration and Transformation - Data Reduction - Descriptive data analytics - measures of central tendency - measures of location of dispersions.

UNIT II

Association Rule Mining: Efficient and Scalable Frequent Item set Mining Methods - Mining Various Kinds of Association Rules - Association Mining to Correlation Analysis - Constraint Based Association Mining - Cluster Analysis: Types of Data in Cluster Analysis - A Categorization of Major Clustering Methods - Partitioning Methods - Hierarchical methods.

UNIT III

Introduction to Streams Concepts - Stream data model and architecture - Stream Computing - Sampling data in a stream - Filtering streams - Counting distinct elements in a stream - Estimating moments - Counting oneness in a window - Decaying window - Real Time Analytics Platform (RTAP) applications - case studies - real time sentiment analysis - stock market predictions.

UNIT IV

Using Graph Analytics for Big Data: Graph Analytics - The Graph Model - Representation as Triples - Graphs and Network Organization - Choosing Graph Analytics - Graph Analytics Use Cases - Graph Analytics Algorithms and Solution Approaches – Centrality Analysis-degree centrality, closeness centrality, and betweenness centrality - Community detection algorithms - Girvan-Newman Algorithm -Label Propagation Algorithm -Fast Greedy Algorithm - Graph QL

UNIT V

NoSQL Databases - Schema-less Models - Increasing Flexibility for Data Manipulation - Key Value Stores - Document Stores - Tabular Stores - Object Data Stores - Graph Databases Hive-Sharding-Hbase - Analyzing big data with twitter - big data for E-Commerce - Big data for blogs - Review of Basic Data Analytic Methods using R.

Text Books:

1. A. Rajaraman, J. Ullman, "Mining Massive Data Sets", 3rd Edition, Cambridge University Press, 2020.
2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, No SQL, and Graph", 2013.

Reference Books:

1.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning, Data Mining, Inference, and Prediction", 2nd ed. 2009, Corr. 9th printing 2017, Springer.
2.	G James, D. Witten, T Hastie, R. Tibshirani, "An Introduction to Statistical Learning: With Applications in R", 2nd Edition, Springer, 2021.
3.	Mohammed J. Zaki, Wagner Meira, "Data Mining and Analysis: Fundamental Concepts and Algorithms", Second Edition Cambridge, 2020.
4.	E. Alpaydin, "Introduction to Machine Learning", 4th Edition, MIT Press, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Evaluate the use of data from acquisition through cleaning, warehousing, analytics, and visualization to the ultimate business decision
CO2	Mine data and carry out predictive modelling and analytics to support business decision-making
CO3	Suggest prescriptive modelling techniques and execute real-time analytical methods on streaming datasets to react quickly to customer needs
CO4	Apply graph analytics on data

Course Code	CSPE54
Course Title	Data Science
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment & End semester examination

Course Learning Objectives (CLO)

CLO1	To understand the data science process and exploration
CLO2	To learn Machine learning algorithms
CLO3	To get a knowledge on types of learning, processes, techniques and models
CLO4	To know about the research that requires the integration of large amounts of data

Course Content:

UNIT I

Introduction to data science - case for data science - data science classification - data science algorithms - Data Science Process - prior Knowledge - Data Preparation - Modeling - Application - Knowledge - Data Exploration - Objectives of data Exploration - Datasets - Descriptive Statistics - Data Visualization - Roadmap for data exploration.

UNIT II

Natural language Processing basics - Language Syntax and Structure - Language Semantics - Natural language Processing - Text Analytics - Text Preprocessing and Wrangling - Understanding Text Syntax and Structure - Feature Engineering for Text Representation - Traditional Feature Engineering Models - bag of words model - bag of N-Grams model - TF - IDF Model - Topic Models - Text Classification - Automated Text Classification - Text Classification Blueprint - Classification Models - Multinomial Naïve Bayes - Logistic Regression - Support Vector Machines - Ensemble Models - Random Forest - Gradient Boosting Machines - Evaluating Classification Models.

UNIT III

Text Similarity and clustering - Essential Concepts - Analyzing term Similarity - Analyzing Document Similarity - Document Clustering - Feature Engineering - K-means Clustering - Affinity Propagation - Ward's Agglomerative Hierarchical Clustering - Semantic Analysis - Exploring Wordnet - Word Sense Disambiguation - Named Entity Recognition - Analyzing Semantic meta Representations - Sentiment Analysis - Unsupervised Lexicon-Based Models - Bing Liu's Lexicon - MPQA Subjectivity Lexicon - Pattern Lexicon - Text Blob Lexicon - AFINN Lexicon - Sent WordNet Lexicon - VADER Lexicon - Classifying Sentiment with Supervised Learning.

UNIT IV

Speech - Phonetics - Speech Sounds and Phonetic Transcription - Articulatory Phonetics - Phonological Categories and Pronunciation variation - Acoustics Phonetics and Signals - Speech Synthesis - Phonetic Analysis - Prosodic Analysis - Diphone Waveform synthesis - Automatic Speech Recognition - Speech Recognition Architecture - Applying Hidden Markov Model to Speech - Feature Extraction: MFCC Vectors - Computing Acoustic Likelihoods - The Lexicon and language Model Search and decoding.

UNIT V

Time series Forecasting - Time series Decomposition - Smoothing based Methods - Regression based Methods - Machine Learning Methods - Performance evaluation - Anomaly Detection - Concepts - Distance based outlier Detection - Density based outlier Detection - Local outlier factor - Feature Selection - Classifying feature selection Methods - Principal Component Analysis - Information theory-based filtering - chi-square based filtering - Wrapper-type feature selection.

Text Books:

1. Vijay Kotu, Bala Deshpande, "Data Science: Concepts and Practice", Elsevier Publications, Second Edition, 2019.
2. Brandon Reagen, Robert Adolf, Paul Whatmough, Gu-Yeon Wei, David Brooks, "Deep Learning for Computer Architects", Morgan Clay Pool Publishers, 2017.

Reference Books:

1.	Ethem Alpaydin, "Introduction to Machine Learning", Third Edition, Adaptive Computation and Machine Learning Series, MIT Press, 2014.
2.	Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Second Edition, Machine Learning and Pattern Recognition Series, Chapman and Hall/CRC, 2014.
3.	Dietmar Jannach, Markus Zanker, "Recommender Systems: An Introduction", Cambridge University Press, 2010.
4.	Dipanjan Sarkar, "Text Analytics with Python: A Practitioner's Guide to Natural Language Processing", A Press, 2019.
5.	Daniel Jurafsky, James H. Martin, "Speech and Language Processing", Pearson, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the data science concepts, techniques and models
CO2	Forecast the time series data
CO3	Learn and apply different mining algorithms and recommendation systems for large volumes of data
CO4	Perform analytics on data streams

Course Code	CSPE55
Course Title	Social Network Analysis
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Recognize the concept of semantic web and related applications
CLO2	Employ learn knowledge representation using ontology
CLO3	Recognize human behavior in social web and related communities
CLO4	Sketch and learn visualization of social networks while investigating various descriptive measures and software to calculate and interpret the results.

Course Contents

UNIT I Introduction

Introduction to Semantic Web: Limitations of current Web - Development of Semantic Web - Emergence of the Social Web - Social Network analysis: Development of Social Network Analysis - Key concepts and measures in network analysis - Electronic sources for network analysis: Electronic discussion networks - Blogs and online communities - Web-based networks - Applications of Social Network Analysis.

UNIT II Modelling, Aggregating and Knowledge Presentation

Ontology and their role in the Semantic Web: Ontology-based knowledge Representation - Ontology languages for the Semantic Web: Resource Description Framework - Web Ontology Language - Modelling and aggregating social network data: State-of-the-art in network data representation - Ontological representation of social individuals - Ontological representation of social relationships - Aggregating and reasoning with social network data - Advanced representations.

UNIT III Extraction and Mining Communities in Web Social Networks

Extracting evolution of Web Community from a Series of Web Archive - Detecting communities in social networks - Definition of community - Evaluating communities - Methods for community detection and mining - Applications of community mining algorithms - Tools for detecting communities - social network infrastructures and communities - Decentralized online social networks - multi-Relational characterization of dynamic social network communities.

UNIT IV Predicting Human Behavior and Privacy Issues

Understanding and predicting human behavior for social communities - User data management - Inference and Distribution - Enabling new human experiences - Reality mining - Context - Awareness - Privacy in online social networks - Trust in online environment - Trust models based on subjective logic - Trust network analysis - Trust transitivity analysis - Combining trust and reputation - Trust derivation based on trust comparisons - Attack spectrum and counter measures.

UNIT V Visualization and Applications of Social Networks

Graph theory - Centrality - Clustering - Node-Edge Diagrams - Matrix representation - Visualizing online social networks - Visualizing social networks with matrix-based representations - Matrix and Node-Link Diagrams - Hybrid representations - Applications - Cover networks - Community welfare - Collaboration networks - Co-Citation networks.

Text Book:

1. Peter Mika, "Social Networks and the Semantic Web", First Edition, Springer 2007.
2. Borko Furht, "Handbook of Social Network Technologies and Applications", First Edition, Springer, 2010.

References

1.	Guandong Xu, Yanchun Zhang, Lin Li, "Web Mining and Social Networking – Techniques and Applications", First Edition, Springer, 2011.
2.	Dion Goh, Schubert Foo, "Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively" IGI Global Snippet, 2008.
3.	Max Chevalier, Christine Julien, Chantal Soule-Dupuy, "Collaborative and Social Information Retrieval and Access: Techniques for Improved User Modelling", IGI Global Snippet, 2009.
4.	John G. Breslin, Alexander Passant, and Stefan Decker, "The Social Semantic Web", Springer, 2009.
5.	Tanmoy Chakraborty Social Network Analysis, Wiley,2021

Course Outcomes (CO)

At the end of the course student will be able

CO1	Develop semantic web related applications
CO2	Describe and represent knowledge using ontology
CO3	Inspect and predict human behavior in social web and related communities
CO4	Organize and visualize social networks

Course Code	CSPE56
Course Title	Human Computer Interaction
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an overview of the concepts relating to the design of human-computer interfaces
CLO2	To understand the theoretical dimensions of human factors involved in the acceptance of computer interfaces
CLO3	To understand the important aspects of implementation of human-computer interfaces
CLO4	To identify the various tools and techniques for interface analysis, design and evaluation

Course Content:

UNIT I

HCI Foundations: Input–output channels - Human memory - Thinking: reasoning and problem solving - Emotion - Individual differences - Psychology and the design of interactive systems - Text entry devices - Positioning - pointing and drawing - Display devices - Devices for virtual reality and 3D interaction - Physical controls - sensors and special devices - Paper: printing and scanning.

UNIT II

Designing - Programming Interactive systems - Models of interaction - Frameworks and HCI - Ergonomics - Interaction styles - Elements of the WIMP interface - The context of the interaction - Experience - engagement and fun - Paradigms for interaction.

Cantered Design and testing - Interaction design basics - The process of design - User focus - Scenarios - Navigation design - Screen design and layout, Iteration and prototyping.

UNIT III

HCI in the software process - Iterative design and prototyping - Design rules - Principles to support usability - Standards and Guidelines - Golden rules and heuristics - HCI patterns.

Implementation support - Elements of windowing systems - Programming the application - Using toolkits - User interface management systems.

UNIT IV

Evaluation techniques - Evaluation through expert analysis - Evaluation through user participation - Universal design - User support.

Models and Theories - Cognitive models - Goal and task hierarchies - Linguistic models - The challenge of display-based systems - Physical and device models - Cognitive architectures.

UNIT V

Collaboration and communication - Face-to-face communication - Conversation - Text-based communication - Group working - Dialog design notations - Diagrammatic notations - Textual dialog notations - Dialog semantics - Dialog analysis and design Human factors and security - Groupware - Meeting and decision support systems - Shared applications and artifacts - Frameworks for groupware - Implementing synchronous groupware - Mixed - Augmented and Virtual Reality.

Text Books:

1. A Dix, Janet Finlay, G D Abowd, R Beale, "Human - Computer Interaction", Pearson Publishers, Third Edition, 2008.
2. Shneiderman, Plaisant, Cohen, Jacobs, "Designing the User Interface: Strategies for Effective Human Computer Interaction", Pearson Publishers, Fifth Edition, 2018.

Reference Books:

1.	Jonathan Lazar, "Research Methods in Human–Computer Interaction", John Wiley & Sons (2017)
2.	NPTEL Course on Human Computer Interaction (HCI): http://nptel.ac.in/courses/106103115/

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and Develop processes and life cycle of Human Computer Interaction
CO2	Analyse product usability evaluations and testing methods
CO3	Apply the interface design standards/guidelines for cross cultural and disabled users
CO4	Categorize, Design and Develop Human Computer Interaction in proper architectural structures

Course Code	CSPE58
Course Title	Text, Speech and Video Analytics
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand classification algorithms for text documents
CLO2	To understand the speech recognition system
CLO3	To know image and video analytic fundamentals
CLO4	To understand the real time use of text, speech, image and video analytics

Course Content:

UNIT I TEXT ANALYSIS

Foundations of natural language processing – Language Syntax and Structure - Text Preprocessing and Wrangling – Text tokenization – Stemming – Lemmatization – Removing stop-words – Feature Engineering for Text representation – Bag of Words model- Bag of N-Grams model – TF-IDF model.

Vector Semantics and Embeddings -Word Embeddings - Word2Vec model – Glove model – FastText model – Overview of Text summarization and Topic Models.

UNIT II SPEECH ANALYSIS

Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths

UNIT III SPEECH RECOGNITION & SYNTHESIS

Hidden Markov Models - Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues - Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – n-grams, context dependent sub-word units - Text-to-Speech Synthesis - Concatenative and waveform synthesis methods, role of prosody, Applications and present status.

UNIT IV FUNDAMENTALS OF IMAGE PROCESSING

Characteristics of Digital Image - Basic relationship between pixels – Fundamental operations on image - Image sampling and quantization – Image transformations - Color models. Basic Techniques of image processing Fundamentals of spatial filtering: spatial correlation and convolution-smoothing blurring- sharpening.

UNIT IV VIDEO PROCESSING & ANALYTICS

Image and Video Segmentation - Detection and Classification Object detection and recognition in image and Video-Texture models Image and Video classification models - Object tracking in Video – Deep models for Image analytics – Deep models for Speech analytics – Deep models for

Video Analytics.

Textbooks:

1. Dipanjan Sarkar, "Text Analytics with Python: A Practical Real-World approach to Gaining Actionable insights from your data", APress,2018
2. Jurafsky and Martin, "Speech and Language Processing", Pearson Prentice Hall, Second Edition, 2008.
3. Rafael C Gonzalez, Richard E Woods, Digital Image Processing, Pearson Education, 4th edition, 2018.

Reference Books:

1.	Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003
2.	Udaya Kamath, John Liu, James whitaker, "Deep learning for NLP and Speech Recognition", Springer, 2019
3.	Caifeng Shan, Fatih Porikli, Tao Xiang, Shaogang Gong, "Video Analytics for Business Intelligence", Springer, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Explain coreference and coherence for text processing
CO2	Use and modify existing algorithms for speech recognition and processing for various applications
CO3	Propose appropriate speech synthesis models for a given application
CO4	Use appropriate image, video processing algorithms for a specific application

OPEN ELECTIVES

Course Code	:	**CSOE11**
Course Title	:	**Big Data Analytics**
Type of Course	:	**PE**
Prerequisites	:	--
Contact Hours	:	

Course Learning Objectives (CLO)

CLO1	To understand the Big Data Platform and its Use cases
CLO2	To Provide an overview of Apache Hadoop
CLO3	To Provide HDFS Concepts and Interfacing with HDFS
CLO4	To understand NoSQL database

Course Contents

UNIT I Introduction to Big Data

Introduction: Big Data - Characteristics of Big Data - Big data management architecture - Examining Big Data Types - Big Data Technology Components - Big data analytics - big data analytics examples - Web Data Overview - Web Data in Action.

UNIT II Hadoop

Introduction: History of Hadoop - Hadoop Ecosystem - Analyzing data with Hadoop - Hadoop Distributed File System - Design - HDFS concepts - Hadoop filesystem - Data flow - Hadoop I / O - Data integrity - Serialization - Setting up a Hadoop cluster - Cluster specification - cluster setup and installation - YARN.

UNIT III MapReduce

Introduction: Understanding MapReduce functions - Scaling out - Anatomy of a MapReduce Job Run - Failures - Shuffle and sort - MapReduce types and formats - features - counters - sorting - MapReduce Applications –Configuring and setting the environment - Unit test with MR unit - local test.

UNIT IV Spark

Installing spark - Spark applications - Jobs - Stages and Tasks - Resilient Distributed databases - Anatomy of a Spark Job Run - Spark on YARN - SCALA: Introduction - Classes and objects - Basic types and operators - built-in control structures - functions and closures - inheritance.

UNIT V NoSQL Databases

Introduction to NoSQL - MongoDB: Introduction - Data types - Creating - Updating and deleing documents - Querying - Introduction to indexing - Capped collections - HBase: Concepts - HBase Vs RDBMS - Creating records - Accessing data - Updating and deleting data - Modifying data - exporting and importing data.

USE CASES: Call detail log analysis - Credit fraud alert - Weather forecast.

Reference Books:

1.	David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, No SQL, and Graph", Morgan Kaufmann/Elsevier Publishers, 2013.
2.	Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2014.
3.	Kim H. Pries, Robert Dunnigan, "Big Data Analytics: A Practical Guide for Managers", CRC Press, 2015.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the characteristics of big data and concepts of Hadoop ecosystem
CO2	Understand the concepts of Scala programming
CO3	Apply Mapreduce programming model to process big data
CO4	Analyze Spark and its uses for big data processing

Course Code	CSOE12
Course Title	Cloud & Grid Computing
Type of Course	OE
Pre-requisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide comprehensive knowledge of fundamental concepts and of grid and cloud computing
CLO2	To demonstrate an understanding of Virtualization, Service models and deployment models of the cloud
CLO3	To describe the programming and software environments of grid and cloud
CLO4	To shed light on the security issues in the grid and the cloud

Course Content:

UNIT I

Overview of Distributed Computing - Cluster Computing - Technologies for Network based systems - Software environments for Distributed Systems - Overview of Services and Service oriented Architecture.

UNIT II

Fundamentals of Grid Computing - Open Grid Services Architecture - Motivation - Functionality Requirements - Practical & Detailed view of OGSA/OGSI - Data intensive grid service models - OGSA services.

UNIT III

Virtual Machines and Virtualization - Implementation levels of Virtualization - Virtualization structures/tools and Mechanisms - Virtualization of CPU - Memory and I/O Devices - Storage Virtualization.

UNIT IV

Cloud Computing - Properties - challenges - Service models - IaaS - PaaS and SaaS Deployment models - Service Composition and orchestration - Architecture design of Compute and Storage cloud - Public Cloud Platforms - Inter Cloud Resource Management.

UNIT V

Grid Security Issues - The Grid Security Infrastructure - Authorization modes in GSI - Possible Vulnerabilities - Cloud security issues - Infrastructure security - Data security - Identity and access management Privacy - Audit and Compliance.

Text Books:

2. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, “Distributed and Cloud Computing from Parallel Processing to the Internet of Things”, Morgan Kaufmann, Elsevier, 2012.

3. Frédéric Magoulès, "Fundamentals of Grid Computing Theory, Algorithms and Technologies", CRC Press, 2010.

Reference Books:

1.	Erl, Thomas, Ricardo Puttini, Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture", Pearson Education, 2013.
2.	Hurwitz, Judith S., Robin Bloor, Marcia Kaufman, Fern Halper, "Cloud Computing for Dummies", John Wiley & Sons, 2010.
3.	Katarina Stanoevska-Slabeva, Thomas Wozniak,Santi Ristol," Grid and Cloud Computing", 1st, Springer Berlin,2014
4.	Krishna P Venkata," Principles of grid computing: concepts and applications", 1st, Delhi Ane Books Pvt. Ltd.,2015

Course Outcomes (CO)

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

CO1	Understand the core concepts of Distributed computing
CO2	Articulate the Virtualization concepts
CO3	Identify the architecture, service models and deployment models of Cloud
CO4	Understand and build secure and reliable Grid and Cloud applications

Course Code	CSOE13
Course Title	Computer Graphics and Multimedia Systems
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basics of various inputs and output computer graphics hardware devices
CLO2	Exploration of fundamental concepts in 2D and 3D computer graphics
CLO3	To know 2D raster graphics techniques, 3D modelling, geometric transformations, 3D viewing and rendering
CLO4	Exploration of fundamental concepts in multimedia systems, file handling, hypermedia

Course Content

UNIT I

Basic of Computer Graphics: Applications of computer graphics - Display devices - Random and Raster scan systems - color models - Graphics Primitives: Points - lines - circles and ellipses as primitives - scan conversion algorithms for primitives. *

UNIT II

Two-Dimensional Graphics: Two dimensional geometric transformations - Matrix representations and homogeneous coordinates - composite transformations - Two-dimensional viewing - viewing pipeline - viewing coordinate reference frame - window-to-viewport coordinate transformation - Two-dimensional viewing functions - clipping operations - point - line - polygon clipping algorithms. *

UNIT III

Three-Dimensional Graphics: Three dimensional concepts - Three dimensional object representations - Polygon surfaces - Polygon tables - Plane equations - Polygon meshes - Curved Lines and surfaces - Quadratic surfaces - Blobby objects - Spline representations - Bezier curves and surfaces - B-Spline curves and surfaces - Transformation and Viewing: Three dimensional geometric and modeling transformations - Translation - Rotation - Scaling - composite transformations - Three dimensional viewing – viewing pipeline - viewing coordinates - Projections - Clipping.*

UNIT IV

Multimedia System Design & Multimedia File Handling: Data and File Formats - Multimedia basics - Multimedia applications - Multimedia system architecture - Evolving technologies for multimedia - Defining objects for multimedia systems - Multimedia data interface standards - Multimedia databases - Compression and decompression - Data and file format standards - Multimedia I/O technologies - Digital voice and audio - Video image and animation - Full motion video - Storage and retrieval technologies.*

UNIT – V

Hypermedia: Multimedia authoring and user interface - Hypermedia messaging - Mobile messaging - Hypermedia message component - Creating hypermedia message - Integrated multimedia message standards - Integrated document management - Distributed multimedia systems. *

*Programming assignments are mandatory.

Text Book

1. J. D. Foley, A. Van Dam, S. K. Feiner, J. F. Hughes, "Computer Graphics: Principles and Practice", Second Edition in C, Addison Wesley, 1997.
2. Donald Hearn, Pauline Baker M, "Computer Graphics", Prentice Hall, New Delhi, 2007.
3. Andleigh, P. K, Kiran Thakrar, "Multimedia Systems and Design", PHI, 2003.

References

1	. F. Rogers, J. A. Adams, "Mathematical Elements for Computer Graphics", Second Edition, Graw Hill Education, 2017
2.	Dave Shreiner, "OpenGL Programming Guide: The Official Guide to Learning OpenGL", Versions 3.0 and 3.1,Seventh Edition, Pearson Addison-Wesley Professional,2009
3.	' Dave Shreiner, "OpenGL Reference Manual: The Official Reference Document to penGL", Version 1.4, Fourth Edition, Addison- Wesley,2004.

Course Outcomes (CO)

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

CO1	Understand the various computer graphics hardware and display technologies
CO2	Implement various 2D and 3D objects transformation techniques and apply viewing technologies into the real-world applications
CO3	Implement multimedia components efficiently
CO4	Understand Hypermedia and distributed multimedia systems

Course Code	CSOE14
Course Title	Distributed Architecture
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop an infrastructure for distributed system and architecture
CLO2	To get knowledge about universal and independent of a specific middleware technology
CLO3	To obtain knowledge about complete CORBA implementation
CLO4	To design the architecture of middleware platforms

Course Content:

UNIT I Introduction

Introduction: Distributed System - Object Model - Middleware - Sample Application - CORBA - Creation process -Application Development - The Bootstrapping Problem - Naming Service.

UNIT II ORB

ORB Architecture - Transport Layer - Presentation Layer - Interoperability Layer - Proxies - Object Services - ORB Design - ORB Functionality - Design of MICO's ORB.

UNIT III Models

Interoperability: Model - Inter-ORB Model - Design of MICO's Interoperability Object Adapters - Terminology - Functionality - Examples of Object Adapter - Design of MICO's POA - Persistence - POA Mediator - Collocation.

UNIT IV Invocation Adapters

Functionality - Static and dynamic Invocation Interface - Design of MICO's DII-Compiler: Invocation Adapters - Compiler Fundamentals - Abstract Syntax Tree for IDL specifications - MICO's IDL Compiler.

UNIT V CORBA

CORBA Components - Web Services - Middleware for Ubiquitous Computing - case study for MICO Implementation and Application of MICO.

Text Books:

- Arno Puder, Kay Römer, Frank Pilhofer, "Distributed Systems Architecture A Middleware Approach", Elsevier, 2006.
- M. van Steen and A.S. Tanenbaum, "Distributed Systems, 4th ed.", distributed- systems.net,2023

Reference Books:

1.	Andreas Christ, Markus, "Architectures for Distributed and Complex M-Learning Systems: Applying Intelligent Technologies", 2010.
2.	Bernard I. Witt, F. Terry Baker, Everett W. Merritt, "Software Architecture and Design: Principles, Models, and Methods", 1993.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the distributed system architecture
CO2	Implement CORBA and MICO
CO3	Design middleware platforms
CO4	Analyse the performance of the distributed systems by running various applications

Course Code	CSOE15
Course Title	Human Computer Interaction
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To provide an overview of the concepts relating to the design of human-computer interfaces
CLO2	To understand the theoretical dimensions of human factors involved in the acceptance of computer interfaces
CLO3	To understand the important aspects of implementation of human-computer interfaces
CLO4	To identify the various tools and techniques for interface analysis, design and evaluation

Course Content:

UNIT I

HCI Foundations - Input–output channels - Human memory - Thinking: reasoning and problem solving - Emotion - Individual differences - Psychology and the design of interactive systems - Text entry devices - Positioning - pointing and drawing - Display devices - Devices for virtual reality and 3D interaction - Physical controls - sensors and special devices - Paper: printing and scanning.

UNIT II

Designing - Programming Interactive systems - Models of interaction - Frameworks and HCI - Ergonomics - Interaction styles - Elements of the WIMP interface - The context of the interaction - Experience - engagement and fun - Paradigms for interaction.

Cantered Design and testing - Interaction design basics - The process of design - User focus - Scenarios - Navigation design - Screen design and layout - Iteration and prototyping.

UNIT III

HCI in the software process - Iterative design and prototyping - Design rules - Principles to support usability - Standards and Guidelines - Golden rules and heuristics - HCI patterns.

Implementation support - Elements of windowing systems - Programming the application - Using toolkits - User interface management systems.

UNIT IV

Evaluation techniques - Evaluation through expert analysis - Evaluation through user participation - Universal design - User support.

Models and Theories - Cognitive models - Goal and task hierarchies - Linguistic models - The challenge of display-based systems - Physical and device models - Cognitive architectures.

UNIT V

Collaboration and communication - Face-to-face communication - Conversation - Text-based communication - Group working - Dialog design notations - Diagrammatic notations - Textual dialog notations - Dialog semantics - Dialog analysis and design Human factors and security - Groupware - Meeting and decision support systems - Shared applications and artifacts - Frameworks for groupware - Implementing synchronous groupware - Mixed - Augmented and Virtual Reality.

Text Books:

1. A Dix, Janet Finlay, G D Abowd, R Beale, "Human-Computer Interaction", Pearson Publishers, Third Edition, 2008.
2. Shneiderman, Plaisant, Cohen, Jacobs, "Designing the User Interface: Strategies for Effective Human Computer Interaction", Pearson Publishers, Fifth Edition, 2018.

Reference Books:

1.	Jonathan Lazar, "Research Methods in Human–Computer Interaction", John Wiley & Sons, 2017
2.	NPTEL Course on Human Computer Interaction (HCI): http://nptel.ac.in/courses/106103115/

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and Develop processes and life cycle of Human Computer Interaction
CO2	Analyze product usability evaluations and testing methods
CO3	Apply the interface design standards/guidelines for cross cultural and disabled users
CO4	Categorize, Design and Develop Human Computer Interaction in proper architectural structures

Course Code	CSOE16
Course Title	Image Processing
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of Digital imaging
CLO2	To understand the fundamentals of Image Processing techniques
CLO3	To under the mathematical transforms applicable to image processing
CLO4	To be familiar with image compression and segmentation
CLO5	Exploration of image processing algorithms

Course Content

UNIT I Introduction
Fundamentals of Image Processing - Applications of Image Processing - Human Visual Perception - Introduction to Image Formation - Sampling and Quantization - Binary Image - Three-Dimensional Imaging - Image file formats - Color and Color Imagery: Perception of Colors. *

UNIT II Image Transformation
Fourier Transforms - Discrete Cosine Transform - Walsh-adamard Transform - Karhaunen-Loeve Transform or PCA - Discrete Wavelet Transform: Wavelet Transform - Extension to 2D Signals - Lifting Implementation of the Discrete Wave Transforms. *

UNIT III Image Enhancement and Restoration
Introduction - Distinction between image enhancement and restoration - Histogram-based Contrast Enhancement - Frequency Domain Methods of Image Enhancement - Noise Modeling - Image Restoration - Image Reconstruction. *

UNIT IV Image Segmentation and Compression
Edge detection - Edge linking via Hough transform - Thresholding - Region based segmentation - Watershed algorithm - Use of motion in segmentation - Need for data compression - Encoder-Decoder model - Types of redundancies - Lossy and Lossless compression. *

UNIT V Recognition of Image Patterns
Introduction - Decision Theoretic Pattern Classification - LDA - Bayesian Decision Theory - Texture and Shape Analysis - Case study - Image mining and Content-Based Retrieval. *

*Programming assignments are mandatory.

Text Book

1. Maria Petrou, Costas Petrou, “Image Processing the Fundamentals”, Second Edition, John-Wiley and Sons Publishers, 2010.
2. Gonzalez, Woods, “Digital Image Processing”, Third Edition (DIP/3e), Prentice Hall, 2008.

References

1	Tinku Acharya, Ajoy K. Ray, "Image Processing Principles and Applications", First Edition, Wiley-Interscience, 2005.
2	Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Second Edition, Gatesmark Publishing, 2009.
3	A.K. Jain, "Fundamentals of Digital Image Processing", PHI, New Delhi, 2015.
4	S E Umbaugh, "Digital Image Processing and Analysis: Application with MATLAB and CVIP Tools", Third Edition, Taylor & Francis, CRC Press, 2018.

Course Outcomes (CO)

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

CO1	Process image enhancement and restoration techniques
CO2	Apply image compression and segmentation Techniques
CO3	Apply transforms for processing of images
CO4	Design and develop image processing applications

Course Code	CSOE17
Course Title	Internet of Things
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the basic issues, policy and challenges in the Internet
CLO2	To get an idea of some of the application areas where Internet of Things can be applied
CLO3	To understand the cloud and internet environment
CLO4	To understand the various modes of communications with Internet
CLO5	To understand about web of things

Course Content

UNIT I Introduction

Definition - Foundations - Challenges and Issues - Identification - Security - Components in internet of things**:** Control Units - Sensors - Communication modules - Power Sources - Communication Technologies - RFID - Bluetooth - Zigbee - Wifi - Rflinks - Mobile Internet - Wired Communication - IoT Platform Overview - Raspberry pi - Arduino boards.*

Unit II IoT Protocols

Protocol Standardization for IoT - M2M and WSN Protocols - SCADA and RFID Protocols - Issues with IoT Standardization - Protocols - IEEE 802.15.4 - BACNet Protocol - Zigbee Architecture - Network layer - APS Layer Security.*

Unit III Resource Management in the Internet of Things

Clustering - Software Agents - Data Synchronization - Clustering Principles in an Internet of Things Architecture - The Role of Context - Design Guidelines - Software Agents for Object Data Synchronization - Types of Network Architectures - Fundamental Concepts of Agility and Autonomy - Enabling Autonomy and Agility by the Internet of Things - The Evolution from the RFID-based EPC Network to an Agent based Internet of Things - Agents for the Behaviour of Objects.*

Unit IV Case Study and IoT Application Development

IoT applications in home infrastructures security Industries - IoT electronic equipments - Use of Big Data and Visualization in IoT - Industry 4.0 concepts - Sensors and sensor Node - Interfacing using Raspberry Pi/Arduino- Web Enabled Constrained Devices.*

Unit V Web of Things

Web of Things versus Internet of Things - Architecture Standardization for WoT - Platform Middleware for WoT - WoT Portals and Business Intelligence - Cloud of Things: Grid/SOA and Cloud Computing - Cloud Standards - Cloud of Things Architecture - Open Source e-Health sensor platform.*

*Programming assignments are mandatory.

Text Books

1. Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective", CRC Press, 2012.
2. Dieter Uckelmann, Mark Harrison, "Architecting the Internet of Things", Springer, 2011.

Reference Books

1.

1.	Arshdeep Bahga, Vijay Madisetti, "Internet of Things (A Hands-On-Approach)", VPT, 2014.
2.	Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key Applications and Protocols", Wiley, 2012.
3.	Luigi Atzori, Antonio Lera, Giacomo Morabito, "The Internet of Things: A Survey", Journal on Networks, Elsevier Publications, October, 2010.
4	*[Online]* http://www.theinternetofthings.eu/what-is-the-internet-of-things

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the components of IoT & analyze various protocols of IoT
CO2	Design portable IoT using appropriate boards
CO3	Develop schemes for the applications of IOT in real time scenarios
CO4	Design business Intelligence and Information Security for WoT

Course Code	CSOE18
Course Title	Machine Learning for Engineering Applications
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide a broad survey of different machine learning approaches and techniques
CLO2	To understand the principles and concepts of machine learning
CLO3	To understand neural networks concepts
CLO4	To learn regression and reinforcement learning
CLO5	To develop programming skills that helps to build real world applications based on machine learning

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Course Contents

UNIT I Introduction

Introduction: Machine learning: What and why? - Types of Machine Learning - Supervised Learning - Unsupervised Learning - The Curse of dimensionality - Over and under fitting - Model selection - Error analysis and validation - Parametric vs. non-parametric models.

UNIT II Machine Learning

Types of Machine Learning - Supervised Learning - Classification models - Naïve Bayes Classifier - Decision trees - Support Vector Machines - KNN model - Dimensionality reduction - PCA.

UNIT III Clustering

Clustering approaches - Mean Shift clustering - Clustering data points and features - Bi-clustering - multi-view clustering - K-Means clustering - K-medians clustering - Expectation Maximization (EM).

UNIT IV Neural Networks

Neural networks - Biological motivation for Neural Network - Neural network Representation - Perceptron - Feed forward networks - Multilayer Networks and Back Propagation Algorithms - Hidden layer representation - Application of neural network.

UNIT V Applications and Tools

Linear models for regression - Reinforcement Learning - Machine Learning Tools - Engineering applications.

Text Books:

1. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
2. Ethem Alpaydin, “Introduction to Machine Learning”, Second Edition, Prentice Hall of India, 2010.

Reference Books:

1.	Laurene Fausett, "Fundamentals of Neural Networks, Architectures, Algorithms and Applications", Pearson Education, 2008
2.	Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
3.	C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
4	Simon Haykin, "Neural Networks and Learning Machines", Pearson 2008.
5	M. Pandey, and S. S. eds. Rautaray, "Machine Learning: Theoretical Foundations and Practical Applications" (Vol. 87). Springer Nature, 2021.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Solve typical machine learning problems
CO2	Design and implement various machine learning algorithms for real-world applications
CO3	Suggest supervised /unsupervised machine learning approaches for any application
CO4	Handle tools of machine learning

Course Code	CSOE19
Course Title	Security Principles
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	**To understand the basics of Information Security**
CLO2	**To know the legal, ethical and professional issues in Information Security**
CLO3	**To know the aspects of risk management**
CLO4	**To become aware of various standards in this area**
CLO5	**To know the technological aspects of Information Security**

Course Content

UNIT I Introduction

History - What is Information Security? - Critical Characteristics of Information - NSTISSC Security Model - Components of an Information System - Securing the Components - Balancing Security and Access - The SDLC - The Security SDLC.

UNIT II Security Investigation

Need for Security - Business Needs - Threats - Attacks - Legal - Ethical and Professional Issues - An Overview of Computer Security - Access Control Matrix - Policy - Security policies - Confidentiality policies - Integrity policies and Hybrid policies.

UNIT III Security Analysis

Risk Management: Identifying and Assessing Risk - Assessing and Controlling Risk - Systems: Access Control Mechanisms - Information Flow and Confinement Problem.

UNIT IV Logical Design

Blueprint for Security - Information Security Policy - Standards and Practices - ISO 17799/BS 7799 - NIST Models - VISA International Security Model - Design of Security Architecture - Planning for Continuity.

UNIT V Physical Design

Security Technology - IDS - Scanning and Analysis Tools - Cryptography - Access Control Devices - Physical Security - Security and Personnel.

Text Books

1. **Michael E Whitman, Herbert J Mattord, "Principles of Information Security", Course Technology Inc , Sixth Edition, 2017.**

References

1.	**Micki Krause, Harold F. Tipton, "Handbook of Information Security Management", Auerbach Publications, Vol. 7,Sixth Edition , 2013.**
2.	**Stuart McClure, Joel Scrambray, George Kurtz, "Hacking Exposed", Tata McGraw Hill, Seventh Edition,2012.**
3.	**Matt Bishop, "Computer Security Art and Science", Addison Wesley Reprint Edition , 2015.**

Course Outcomes (CO)

At the end of the course student will be able

CO1	**Understand the basics of information security and various standards in the Information Security System**
CO2	**Illustrate the legal, ethical and professional issues in information security**
CO3	**Demonstrate the aspects of risk management**
CO4	**Design and implementation of Security Techniques.**

Course Code	CSOE20
Course Title	Soft Computing
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Describe and understand the concepts of feed forward &feedback neural networks
CLO2	Recognize the concept of fuzziness involved in various systems
CLO3	Expose the ideas about genetic algorithm
CLO4	Compare about FLC and NN toolbox
CLO5	Design algorithm for optimization problem

Course Content:

UNIT I Introduction

Introduction of soft computing - soft computing vs. hard computing - various types of soft computing techniques - applications of soft computing - Neuron-Nerve structure and synapse - Artificial Neuron and its model - activation functions - Neural network architecture - single layer and multilayer feed forward networks - McCullochPitts neuron model - perceptron model - MLP-back propagation learning methods - effect of learning rule coefficient. *

UNIT II Architecture

Counter propagation network - architecture - functioning & characteristics of counter - Propagation network - Hopfield/Recurrent network - configuration - stability constraints - associative memory - characteristics - limitations and applications - Hopfield v/s Boltzmann machine - Adaptive Resonance Theory - Architecture - classifications - Implementation and training - Associative Memory. *

UNIT III Fuzzy Systems

Different faces of imprecision - inexactness - Ambiguity - Undecidability - Fuzziness and certainty - Fuzzy sets and crisp sets - Intersections of Fuzzy sets - Union of Fuzzy sets - the complement of Fuzzy sets - Fuzzy reasoning - Linguistic variables - Fuzzy propositions - Fuzzy compositional rules of inference - Methods of decompositions and defuzzification. *

UNIT IV Optimization Algorithm

Basic concept of Genetic algorithm and detail algorithmic steps - adjustment of free Parameters - Solution of typical control problems using genetic algorithm - Concept on some other search techniques like tabu search and ant colony - search techniques for solving optimization problems. *

UNIT V MATLAB Tool Box for FUZZY Logic and Neural Network

GA application to optimization problems - Case studies: Identification and control of linear and nonlinear dynamic systems using MATLAB - Neural Network toolbox - Stability analysis of Neural Network interconnection systems - Implementation of fuzzy logic controller using MATLAB fuzzy logic toolbox - Stability analysis of fuzzy control systems. *

Text Books:

1. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Third Edition, Wiley India, 2012.
2. Zimmermann H. J., "Fuzzy Set Theory and its Applications", Springer International Edition, 2011.

Reference Books:

1.	David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.
2.	Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", First Edition, Pearson Education, 1993.
3.	W. T. Miller, R. S. Sutton, P. J. Webros, "Neural Networks for Control", MIT Press, 1996.
4.	Herniter, Marc E., "Programming in MATLAB", Brooks/Cole-Thomson Learning, 2001.
5.	Timothy J. Ross, "Fuzzy Sets and Fuzzy Logic with Engineering Applications", Wiley India, 4ed, 2021.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend machine learning and soft computing techniques in solving real world applications
CO2	Design and develop ML techniques with assistance of MATLAB
CO3	Visualize and analyze behavioural pattern to develop evolutionary algorithm
CO4	Design Algorithm for classification Problems

Course Code	CSOE21
Course Title	Software Project Management
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Mathematical Case Study

Course Learning Objectives (CLO)

CLO1	Recognize basic concepts and issues of software project management.
CLO2	Emphasize successful software projects that support organization's strategic goals.
CLO3	Comprehend software quality issues.
CLO4	Comprehend software risk issues.
CLO5	Analyse SPM tools.

Course Content:

UNIT I SPM Concepts
Definition - components of SPM - challenges and opportunities - tools and techniques – managing human resource and technical resource - costing and pricing of projects - training and development –project management techniques. *

UNIT II Software Measurements
Monitoring & measurement of SW development - cost - size and time metrics - methods and tools for metrics – progress evaluation techniques – issues of metrics in multiple projects. *

UNIT III Software Quality
Quality in SW development - quality assurance - quality standards and certifications - the process and issues in obtaining certifications - the benefits and implications for the organization and its customers - change management. *

UNIT IV Risk Issues and Maintenance
The risk issues in SW development and implementation - identification of risks - resolving and avoiding risks - tools and methods for identifying risk management. - Software Maintenance and its types – Software Reengineering*

UNIT V SPM Tools
Software project management using Primavera & Redmine - case study on SPM tools. *

Textbooks:

1. Richard H. Thayer, “Software Engineering Project Management”, II Edition, John Wiley & Sons, 2001.

2. Royce, Walker, “Software Project Management”, Pearson Education, 2002.

Reference Books:

1.	Timothy C. Lethbridge, and Robert Laganiere, "Object Oriented Software Engineering", McGraw Hill Education, Second Edition, 2005.
2.	Kelker S. A., "Software Project Management", Prentice Hall, 2003.
3.	Kan, Stephen H., "Metrics and Models in Software Quality Engineering", Addison-Wesley Longman Publishing Co. Inc., 2002.
4	Galin, Daniel, "Software Quality Assurance: From Theory to Implementation", Pearson Education India, 2004
5	Charette, Robert N., "Software Engineering Risk Analysis and Management", New York: McGraw Hill, 1989

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and develop project modules and assign resources
CO2	Comprehend and analyse estimation, scheduling and risk management metrics
CO3	Analyse Quality Management tools and charts
CO4	Analyse Mathematical Proof for above on real time case studies

Course Code	CSOE22
Course Title	Software Testing and Practices
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Summarize to learn the criteria for test cases
CLO2	Develop and design test cases
CLO3	Analyse test management and test automation techniques
CLO4	Assess test metrics and measurements
CLO5	Differentiate Test monitoring and controlling

Course Content:

UNIT I Introduction

Software testing - The Role process in Software Quality - Testing as a process - Overview of testing maturity model - software testing definition - Software Testing Principles - Origin of defects - Defect classes - the defect Repository and Test Design.

UNIT II Test Case Design Strategies

Testing Strategies: Testing design strategies - Test case design strategies - Black box testing - Random Testing - Equivalence partitioning - Boundary value analysis - Cause-and-Effect - State transition - Error Guessing - COTS - White box testing techniques - Statement coverage - Branch Coverage - Condition coverage - Decision/Condition coverage - Multiple condition coverage - Dataflow coverage - Mutation testing.

UNIT III Levels of Testing

The Need for Levels of Testing - unit test - Planning - Designing the unit tests - Integration test - Integration Strategies for Procedure and Functions - Integration strategies for Classes - Integration test planning - System Test: Functional Testing - Performance Testing - Stress Testing - Configuration Testing - Security Testing - Recovery Testing - Regression testing - Alpha-Beta and Acceptance Tests.

UNIT IV Object Oriented Testing

Testing Object Oriented Software: Unit Testing in OO Context - Integration Testing in OO Context - OO testing methods - Class level testing - Interclass test case design - testing for real time system

UNIT V Test Controlling and Monitoring

Controlling and Monitoring: Measurements and Milestone for Controlling and Monitoring: Status - Productivity - Cost - Error - fault and Failures - Effectiveness - Criteria for Test Completion - Reviews as testing Activity: Inspection Walkthrough - Components of review plan - testing for web application - Component level testing - clean room tests.

Text Books:

1. Ilene Burnstein, "Practical Software Testing", First Indian Reprint, Springer-Verlag, 2004.
2. S. Desai and A. Srivastava, "Software testing: A practical approach", PHI Learning Pvt. Ltd., 2016.

Reference Books:

1.	Ali Behforooz, Frederick J Hudson, "Software Engineering Fundamentals", Oxford University Press, New York, 2003.
2.	William Perry, "Effective Methods for Software Testing", John Wiley & Sons, Second Edition, USA, 2000.
3.	Boris Beizer, "Software Testing Techniques", Second Edition, Van Nostrand Reinhold, New York, 1990.
4	Aditya P. Mathur, "Foundations of Software Testing Fundamental Algorithms and Techniques", Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2008.
5	B. Homès, "Fundamentals of software testing", John Wiley & Sons, 2024.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design test cases suitable for a software development for different domains
CO2	Prepare test planning based on the document
CO3	Document test plans and test cases designed
CO4	Use the automated testing tools to check the behaviour of the real time application

Course Code	CSOE23
Course Title	Web Technology
Type of Course	OE
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Describe basics of Web Designing using HTML, DHTML, and CSS
CLO2	Categories the basics about Client-side scripts and Server-side scripts
CLO3	Classify web application
CLO4	List Regular Expressions
CLO5	Create Database connectivity

Course Content:

UNIT I Web Page Designing
HTML - List - Tables - Images - Forms - Frames - Cascading Style sheets, * XML Document type definition - XML Schemas, * Document Object model.

UNIT II Scripting
Java Script - Control statements - Functions - Arrays - Objects - Events - Dynamic HTML with Java Script - Ajax. *

UNIT III Web Application
Web servers - IIS (XAMPP - LAMPP) and Tomcat Servers - Java Web Technologies - Servlets – Java Server Pages - Java Server Faces - Web Technologies in NetBeans - Building a Web Application in NetBeans - JSF Components - Session Tracking - Cookies. *

UNIT IV PHP Programming
PHP: Basics - String Processing and Regular Expressions - Form Processing and Business Logic - Using Cookies * - Dynamic Content - Operator Precedence Chart.

UNIT V JDBC
Database Connectivity with MySQL - Servlets - JSP - PHP, * Case Studies - Student information system - Health Management System.

*Programming assignments are mandatory.

Text Books:

1. Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, “Internet & World Wide Web How to Program”, Fifth Edition, Deitel Series, 2012.
2. Jason Gilmore, “Beginning PHP and MySQL from Novice to Professional”, Fourth Edition, Apress Publications, 2010.

Reference Books:

1.	Robert W. Sebesta, "Programming with World Wide Web", Eighth Edition, Pearson, 2021.
2.	David William Barron, "The World of Scripting Languages", Wiley Publications, 2009.
3.	Breitman, Karin, Marco Antonio Casanova, Walt Truskowski, "Semantic Web: Concepts, Technologies and Applications", Springer Science & Business Media, 2007.
4.	Khan, Badrul Huda et al., "Web-Based Instruction", Educational Technology, 2001

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Build real world applications using client side and server-side scripting languages
CO2	Design and develop an e-governance application using web technology
CO3	Design Database connectivity with JSP
CO4	Design case study for student Information System and Health Management system

MINOR ELECTIVES

Course Code	CSMI11
Course Title	Data Structures and Algorithms
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment& End Semester Examination

Course Learning Objectives (CLO)

CLO1	To understand the various techniques of sorting and searching
CLO2	To design and implement arrays, stacks, queues, and linked lists
CLO3	To understand the complex data structures such as trees and graphs
CLO4	To design and implement various programming paradigms and its complexity

Course Content:

UNIT I Development of Algorithms
Notations and analysis - Storage structures for arrays - Sparse matrices - Stacks and Queues: Representations and applications - linked lists - Doubly linked lists - Circular linked lists.

UNIT II Trees
Preliminaries - Binary Trees - Search Tree ADT - Binary Search Trees - Hashing: ADT Hash Function - Separate Chaining - Open Addressing - Rehashing - Extendible Hashing.

UNIT III Graphs
Representation of graphs - BFS - DFS - Topological sort - shortest path problems - Dijkstra's algorithm - Floyd-War shall - Minimum spanning trees - prims algorithm - Kruskal algorithm.

Unit IV Algorithmic Paradigms
Divide and Conquer method - Strassen's matrix multiplication - Greedy method - Knapsack problem - Job sequencing with deadlines - Dynamic Programming - Travelling salesman problem.

UNIT V Searching and Sorting Techniques
Selection - Bubble - Insertion - Merge - Quick - Radix sort - Address calculation - Linear search - Binary search.

Text Books:

1. J. P. Tremblay, P. G. Sorenson, “An Introduction to Data Structures with Applications”, Second Edition, Tata McGraw Hill, 1981.
2. M. Tenenbaum, Augestien, “Data Structures using C”, Third Edition, Pearson Education, 2007.
3. Narasimha Karumanchi, “Data Structures and Algorithms Made Easy: Data Structures and Algorithmic Puzzles”, Fifth Edition, CareerMonk Publications, 2016.

Reference Books:

1.	Sartaj Sahni, "Data Structures, Algorithms and Applications in C++", Universities Press (I) Pvt. Ltd., 2008
2.	Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Fourth Edition, Pearson, 2022. ISBN: 978-0132847377.
3.	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", Fourth Edition, MIT Press, 2022. ISBN: 978-0262046305.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand and Analyse Algorithms and Data Structures
CO2	Develop and Apply Tree and Graph Algorithms
CO3	Utilize Advanced Algorithmic Paradigms
CO4	Master Searching and Sorting Techniques

Course Code	CSMI12
Course Title	Computer Organization
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic hardware and software issues of computer organization
CLO2	To understand how computations and data storage are performed at machine level
CLO3	To understand the memory hierarchies, cache memories and virtual memories
CLO4	To learn the different ways of communication with I/O devices

Course Content:

UNIT I

Introduction - Technologies for building Processors and Memory - Performance - The Power Wall operations of the Computer Hardware - Operands - Signed and Unsigned numbers - Representing Instructions - Logical Operations - Instructions for Making Decisions.

UNIT II

MIPS Addressing for 32-Bit Immediate Addresses - Parallelism and Instructions: Synchronization - Translating and Starting a Program - Addition and Subtraction - Multiplication - Division - Floating Point - Parallelism and Computer Arithmetic: Subworld Parallelism - Streaming SIMD Extensions.

UNIT III

Logic Design Conventions - Building a Datapath - A Simple Implementation Scheme - overview of Pipelining - Pipelined Datapath - Data Hazards: Forwarding versus Stalling - Control Hazards - Exceptions - Parallelism via Instructions.

UNIT IV

Memory Technologies - Basics of Caches - Measuring and Improving Cache Performance - Dependable Memory Hierarchy - Virtual Machines - Virtual Memory - Using FSM to Control a Simple Cache - Parallelism and Memory Hierarchy: Redundant Arrays of Inexpensive Disks.

UNIT V

Disk Storage and Dependability - Parallelism and Memory Hierarchy: RAID levels - Performance of storage systems - Introduction to multithreading clusters - message passing multiprocessors.

Text Books:

1. David A. Patterson, John L. Hennessey, “Computer Organization and Design, The Hardware/Software Interface”, Sixth Edition, Morgan Kauffman/Elsevier, 2021.
2. Smruti Ranjan Sarangi, “Computer Organization and Architecture”, McGraw Hill Education, 2015.

Reference Books:

1.	V. Carl Hamacher, Zvonko G. Varanesic, Safat G. Zaky, "Computer Organization", Sixth Edition, McGraw Hill Inc., 2012.
2.	William Stallings, "Computer Organization and Architecture", 11th Edition, Pearson Education, 2022.
3.	Andrew S. Tanenbaum, Todd Austin "Structured Computer Organization" Sixth edition, Pearson Education India, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the architecture and functionality of central processing unit
CO2	Analyse the hardware and software issues and the interfacing
CO3	Work out the tradeoffs involved in designing a modern computer system
CO4	Understand the various memory systems and I/O communication

Course Code	CSMI13
Course Title	Operating Systems
Type of Course	MI
Pre-requisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CLO1	To provide basic knowledge about the services rendered by operating systems
CLO2	To explain the various issues related to process management
CLO3	To provide a detailed discussion of the various memory management techniques
CLO4	To discuss the various file-system design and implementation issues
CLO5	To discuss how the protection domains, help to achieve security in a system

Course Content:

UNIT I
Basic OS Concepts - User's view of the OS - Architectural support - OS services - OS structures - System calls - Building and Booting OS - Process - Threads - Multithreading.

UNIT II
Thread and process scheduling - Types of schedulers - Scheduling Policies – Inter-process synchronization - Critical Section problem - Hardware and Software solutions.

UNIT III
Semaphores - Monitors – Inter-process communication - Deadlocks: Characterization - Handling of deadlocks - Prevention - Avoidance - detection and recovery.

UNIT IV
Memory Management - Contiguous allocation - Static and dynamic partitioned memory allocation - Non-contiguous allocation - Paging - Segmentation - Virtual Memory - Demand Paging.

UNIT V
Need for files - File abstraction - File naming - File system organization - File system optimization - Reliability - Security and protection - I/O management and disk scheduling - Recent trends and development.
Case Study: Linux and Windows OS

Text Books:

1. Silberschatz, Galvin, Gagne, “Operating System Concepts”, Tenth Edition, John Wiley and Sons, 2018.
2. Remzi H. Arpaci-Dusseau, “Operating Systems: Three Easy Pieces”, First Edition, Amazon Digital Services,2018

Reference Books:

1.	William Stallings, "Operating Systems – Internals and Design Principles", Eighth Edition, Pearson Publications, 2014.
2.	Andrew S. Tanenbaum, "Modern Operating Systems", Fourth Edition, Pearson Publications, 2014.

Course Outcomes (CO)

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

CO1	Comprehend the techniques used to implement the process manager
CO2	Comprehend virtual memory abstractions in operating systems
CO3	Design and develop file system interfaces
CO4	Design protection mechanisms for securing the system

Course Code	CSMI14
Course Title	Database Management Systems
Type of Course	MI
Pre-requisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Objectives

CLO1	To learn data models, conceptualize and depict a database system using ER diagram
CLO2	To understand the internal storage structures in a physical DB design
CLO3	To know the fundamental concepts of transaction processing techniques
CLO4	To understand the concept of Database Design in Normalization techniques
CLO5	To know the manipulation of SQL Queries

Course Contents

UNIT I Introduction

Purpose of Database System - Views of data - Data Models - Database Languages - Database System Architecture - components of DBMS - Entity - Relationship model (E-R model) - E-R Diagram notation - Examples.

UNIT II Relational Model

Relational Data Model - Concept of relations - schema-instance distinction - keys - integrity rules - relational algebra operators - SQL: data definition - data manipulation - aggregate function - Null Values - nested sub queries - Joined relations - Work with MySQL Workbench.

UNIT III Database Design

Dependencies and Normal forms - dependency theory - functional dependencies - Armstrong's axioms for FD's - closure of a set of FD's - minimal covers - definitions of 1NF - 2NF - 3NF and BCNF - 4NF - 5NF, decompositions and desirable properties of them.

UNIT IV Transaction management

ACID properties - serializability and concurrency control - Lock based concurrency control (2PL - Deadlocks) - database recovery management.

UNIT V Implementation Techniques

Overview of Physical Storage Media - Magnetic Disks - RAID - Tertiary storage - Organization of Records in Files - Indexing and Hashing - Ordered Indices - primary - secondary index structures - Static Hashing - Dynamic Hashing.

Text Books

1. Silberschatz, Henry F. Korth, S. Sudharshan, “Database System Concepts”, Fifth Edition, Tata McGraw Hill, 2006.
2. J. Date, A. Kannan, S. Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

Reference Books

1.	Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", 7th Edition, Pearson/Addision Wesley, 2017.
2.	Raghu Ramakrishnan, Johannes Gehrke "Database Management Systems", Third Edition, McGraw Hill, 2014.
3.	S. K. Singh, "Database Systems Concepts, Design and Applications", 2nd Edition, Pearson Education, 2011.

Course Outcomes

Upon completion of this course, the students will be able to:

CO1	Install, configure, and interact with a relational database management system
CO2	Master the basics of SQL and construct queries using SQL
CO3	Design and develop a large database with optimal query processing
CO4	Design the database with normalization techniques and develop efficient storage scheme of saving and retrieving Records and Files

Course Code	CSMI15
Course Title	Software Engineering
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the Software Engineering Practice
CLO2	To understand the Software Engineering Process Models
CLO3	To understand Design Engineering, Web applications
CLO4	To gain knowledge of the software testing
CLO5	To understand Software Project Management

Course Content

UNIT I

Introduction: Role of Software Engineer - Software Components - Software Characteristics - Software Crisis - Software Engineering Processes - Similarity and Differences from Conventional Engineering Processes - Quality Attributes.

Assessment: How Software Engineering Changes? Software Development Life Cycle (SDLC) Models: Water Fall Model, Prototype Model, Spiral Model, Evolutionary Development Models, Iterative Enhancement Models, Choosing a social relevant problem, Summary Team Report.

UNIT II

Requirement Engineering Process: Elicitation - Analysis - Documentation - Review and Management of User Needs - Feasibility Study - Information Modeling - Data Flow Diagrams - Entity Relationship Diagrams - Designing the architecture.

Assessment: Impact of Requirement Engineering in their problem, Decision Tables, SRS Document, IEEE Standards for SRS, Architectural design, component level design, user interface design, WebApp Design, Submission of SRS Document for Team Project.

UNIT III

Quality concepts - Review techniques - Software Quality Assurance (SQA): Verification and Validation - SQA Plans - Software Quality Frameworks.

Assessment: Framing SQA Plan, ISO 9000 Models, SEI-CMM Model and their relevance to project Management, other emerging models like People CMM.

UNIT IV

Testing Objectives - Unit Testing - Integration Testing - Acceptance Testing - Regression Testing - Testing for Functionality and Testing for Performance - Top-Down and Bottom-Up Testing - Software Testing Strategies - Strategies: Test Drivers and Test Stubs - Structural Testing (White Box Testing) - Functional Testing (Black Box Testing) - Testing conventional applications - object oriented applications - Web applications - Formal modeling and verification - Software configuration management - Product metrics.

Assessment: Team Analysis in Metrics Calculation.

UNIT V

Project Management Concepts - Process and Project Metrics - Estimation for Software projects - Project Scheduling - Risk Management - Maintenance and Re-engineering. Assessment: Preparation of Risk mitigation plan.

Text Book

1. R. S. Pressman, "Software Engineering: A Practitioners Approach", Seventh Edition, McGraw Hill, 2010.
2. Rajib Mall, "Fundamentals of Software Engineering", Third Edition, PHI Publication, 2009.
3. Pankaj Jalote, "Software Project Management in Practice", Pearson Education, New Delhi, 2002

Course Outcomes (CO)

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

CO1	Assess each module given the overall Software engineering practice
CO2	Comprehend the systematic methodologies involved in SE
CO3	Design and develop a software product in accordance with SE principles
CO4	Design risk mitigation plans for software products.

Course Code	CSMI16
Course Title	Computer Networks
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives (CLO)

CO1	To provide insight about fundamental concepts and reference models (OSI and TCP/IP) and its functionalists
CO2	To gain comprehensive knowledge about the principles, protocols, and significance of Layers in OSI and TCP/IP
CO3	To know the implementation of various protocols and cryptography techniques
CO4	Learn the flow control and congestion control algorithms

Course Contents

UNIT I Data Communications

Data Transmission - Multiplexing - Data Encoding Techniques - Introduction to computer networks - Network - Topologies - Reference Models: ISO/OSI Model and TCP/IP Model.

UNIT II Physical Layer

Transmission Media - Analog signals - Digital Signals - Data Link Layer - Error Detection and Correction - Parity - LRC - CRC - Hamming Code - Flow Control and Error Control - Stop and wait - ARQ - Sliding window - IEEE 802.3 Ethernet.

UNIT III Network Layer

Packet Switching and Circuit Switching - IP addressing methods - Subnetting - Supernetting - Routing Protocols: IP - ARP - RARP - DHCP - Routing Algorithms: Distance Vector Routing - Link State Routing.

UNIT IV Transport Layer

Transport Services - UDP - TCP - Congestion Control - Quality of Services (QOS).

UNIT V Application Layer

Domain Name Space (DNS) - Electronic Mail - HTTP - WWW.

Text Books

1. Andrew S. Tanenbaum, David J. Wetherall, “Computer Networks”, Fifth Edition, Prentice Hall, 2011.
2. Behrouz A. Foruzan, “Data Communication and Networking”, Fifth Edition, Science Engineering & Math Publications, 2013.

Reference Books

1.	W. Stallings, "Data and Computer Communication", Tenth Edition, Pearson Education, 2014.
2.	Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Fifth Edition, Morgan Kaufmann Publishers, 2011.
3.	Nader. F. Mir, "Computer and Communication Networks", Pearson Prentice Hall Publishers, 2010.
4.	Douglas E. Comer, "Internetworking with TCP/IP, Vol 1: Principles, Protocols, and Architecture", Sixth Edition, Pearson, 2013.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Gain insight about basic network theory and layered communication architectures
CO2	Identify the components required to build different types of networks
CO3	Choose the required functionality at each layer for given application
CO4	Trace the flow of information from one node to another node in the network

Course Code	CSMI17
Course Title	Artificial Intelligence
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Semester Assessment

Course Learning Objectives (CLO)

CLO1	To understand the various characteristics of Intelligent agents
CLO2	To learn the different search strategies in AI
CLO3	To learn to represent knowledge in solving AI problems
CLO4	To understand the ways of planning and acting in the real world
CLO5	To know about the models behind the AI application

Course Content:

UNIT I Introduction

Introduction - Definition - Future of Artificial Intelligence - Characteristics of Intelligent Agents Typical Intelligent Agents - Problem Solving Approach to Typical AI problems.

UNIT II Problem Solving Methods

Problem solving Methods - Search Strategies - Uninformed - Informed - Heuristics - Local Search Algorithms and Optimization Problems - Searching with Partial Observations - Backtracking Search - Performance of search algorithms.

UNIT III Knowledge Representation

First Order Predicate Logic - Unification - Forward Chaining - Backward Chaining - Resolution - Knowledge Representation using First order Predicate logic - Reasoning Systems.

UNIT IV Planning

Planning with state-space search - partial-order planning - planning graphs - planning and acting in the real world - Plan generation systems.

UNIT V Uncertain Knowledge and Reasoning

Uncertainty - review of probability - probabilistic Reasoning - Bayesian networks - inferences in Bayesian networks - Temporal models - Hidden Markov mode

Text Books:

1. S. Russel, P. Norvig, "Artificial Intelligence – A Modern Approach", Pearson Education, Third Edition, 2015.

Reference Books:

1.	Kevin Night, Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill, Third Edition, 2017.
2.	Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Ability to design a plan for the real-world problems and mapping it to the digital world
CO2	Suggest appropriate search strategies for any AI problem
CO3	Appreciate the uncertainty in designing AI systems and propose algorithms for the same
CO4	Ability to identify problems that are amenably solved by AI methods

Course Code	CSMI18
Course Title	Internetworking Principles
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous assessment and End semester examination

Course Learning Objectives (CLO)

CO1	To provide insight about networks, topologies, and the key concepts
CO2	To gain comprehensive knowledge about the layered communication architectures and its functionalities
CO3	To understand the principles, key protocols, design issues, and significance of each layers in ISO and TCP/IP
CO4	To know the implementation of various layers

Course Contents

UNIT I Network Topology

Review of Reference Models - Topology and switching - IEEE Standard 802 from Ethernet - Token Bus - Token Ring and Wireless LAN - Connecting Devices.

UNIT II Introduction to IPV4

IPv4 headers - IP forwarding - Host Processing of IP datagrams - DHCP and Auto-configuration - Firewalls and NAT - ICMPv4 - IP Fragmentation - DNS - Broadcasting and Local Multicasting - IGMP - Routing Protocols.

UNIT III IPV6

IPv6 Transition issues - Protocol basics - Addressing - Options and Extension headers - ICMPv6 - Neighbor Discovery - Routing - Autoconfiguration - Multicast Listener Discovery (MLD) - IPv6 and DNS.

UNIT IV Transmission Control Protocol

Transmission Control Protocol (TCP) - TCP Connection Management - TCP Data Flow and Window Management - Stream Control Transmission Protocol (SCTP) - Services - SCTP Association management - SCTP flow and error control.

UNIT V Overview of Mobile IP

Need for Mobile IP - Overview of Mobile IP - Details of Mobile IP - Tunneling - Mobility for IPv6 - Applications of Mobile IP – Security primer - Campus Mobility - Internet wide mobility - A service provider perspective.

Text Books

1. W. Richard Stevens, G. Gabrani, “TCP/IP Illustrated: The Protocols”, Pearson, 2011.
2. Peter Loshin, Morgan Kaufmann, “IPv6: Theory, Protocol, and Practice”, Second Edition, 2003.

Reference Books:

1.	James Solomon, "Mobile IP: The Internet Unplugged", First Edition, Pearson Education, 2008.
2.	Kevin R. Fall, W. Richard Stevens, "TCP/IP Illustrated, Vol. 1 - The Protocols", Second Edition, Addison-Wesley, 2012.
3.	Silvia Hagen, "IPv6 Essentials", Second Edition, O'Reilly Media, 2006.
4.	Charles E. Perkins, "Mobile IP: Design Principles and Practices", First Edition, Pearson Education, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Gain insight about basic network theory and layered communication architectures
CO2	Configure and troubleshoot basic IPv4 network settings, such as IP addresses, subnet masks, default gateways, and DNS servers
CO3	Familiarize about the basics of IP addressing, subnetting, and routing in IPv6 networks
CO4	Desing and develop a mobile IP

Course Code	CSMI19
Course Title	Web Application Development
Type of Course	MI
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the various components of web development and develop simple web applications
CLO2	To learn Node.js features and applications
CLO3	To develop applications with MongoDB
CLO4	To understand the role of Angular and Express in web applications

Course Content:

UNIT I BASICS OF WEB APP

Understanding the Basic Web Development Framework – User – Browser – Webserver – Backend Services – MVC Architecture – Understanding the different stacks –The role of Express – Angular – Node – Mongo DB – React

UNIT II NODE JS

Basics of Node JS – Installation – Working with Node packages – Using Node package manager – Creating a simple Node.js application – Using Events – Listeners –Timers – Callbacks – Handling Data I/O – Implementing HTTP services in Node.js

UNIT III MONGO DB

Understanding NoSQL and MongoDB – Building MongoDB Environment – User accounts – Access control – Administering databases – Managing collections – Connecting to MongoDB from Node.js – simple applications

UNIT IV EXPRESS AND ANGULAR

Implementing Express in Node.js – Configuring routes – Using Request and Response objects – Angular – Typescript – Angular Components – Expressions – Data binding – Built-in directives

UNIT V REACT

MERN STACK – Basic React applications – React Components – React State – Express REST. APIs – Modularization and Webpack – Routing with React Router – Server-side rendering.

Text book:

1. Brad Dayley, Brendan Dayley, Caleb Dayley, 'Node.js, MongoDB and Angular Web Development', Addison-Wesley, Second Edition, 2018

2. Vasan Subramanian, 'Pro MERN Stack, Full Stack Web App Development with Mongo, Express, React, and Node', Second Edition, Apress, 2019.

Reference Books:

1.	Chris Northwood, 'The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer', Apress; 1st edition, 2018.
2.	Kirupa Chinnathambi, 'Learning React: A Hands-On Guide to Building Web Applications Using React and Redux', Addison-Wesley Professional, 2nd edition, 2018

Course outcomes

At the end of the course student will be able

CO1	Understand the various stacks available for web application development
CO2	Use Node.js, features of Angular and Express for application development
CO3	Develop applications with MongoDB
CO4	Develop React applications

HONOURS

Course Code	CSHO11
Course Title	Software Defined Networking
Type of Course	HO
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment and End Assessment

Course Learning Objectives

CLO1	Analyze reduced Complexity of Network Operation
CLO2	Describe and understand the concepts of minimize Layer and maximize Network Resources
CLO3	Evaluate and understand the Faster Time to Revenue for New Applications
CLO4	Memorize Data center and its usage
CLO5	Illustrate about Big data

Course Contents

UNIT I Introduction

Introduction - Control Plane - Data Plane - Distributed Control Planes - IP and MPLS - Creating the IP Underlay - Convergence Time - Load Balancing High Availability - Creating the MPLS Overlay - Replication - Centralized Control Planes – Logical Versus Litera - ATM/LANE - Route Servers - Wire Protocol - FAWG - Config and Extensibility - Architecture - Hybrid Approaches - Ships in the Night - Dual Function Switches.*

UNIT II Interface

VMWare - Nicira - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight - Layer 3 Centric - L3VPN - Path Computation Element Server - Plexxi Affinity - Cisco OnePK - Management Interface - Network Divide - Modern Programmatic Interfaces - Modern Orchestration.*

UNIT III Data Center

Multitenant Data Center - Virtualized Multitenant Data Center - SDN Solutions for Data Center Network - VLANs - EVPN - VxLan - NVGRE - Virtualization and Data Plane I/O - Services Engineered Path - Service Locations and Chaining - NEV at ETSI - Non-ETSI NEV Work.*

UNIT IV Topology

Network Topology - Traditional Methods - LLDP - BGP-TE/LS - ALTO - I2RS - Build Code First - The Juniper SDN Framework(s) - Open Daylight Controller/Framework - Policy.*

UNIT V Technology

Bandwidth Scheduling - Manipulation - Calendaring - Bandwidth Calendaring - Big Data and Application Hyper - Virtualization for Instant CSPF - Expanding Technology - Use Cases for Data Center Overlays - Big Data - Network Function Virtualization - Data Center Orchestration - Puppet - Network Function Virtualization - Optimized Big Data - Firewall as Service - Network Access Control Replacement - Virtual Firewall - Feed Back and Optimization - Intrusion Detection/Threat Mitigation.*

*Programming Assignments are mandatory

Text Books

1. Thomas D. Nandeau, Ken Gray, “Software Defined Networks”, First Edition, O’ Reilly Media Inc., 2013.
2. FEI HU, “Network Innovation through OpenFlow and SDN: Principles and Design”, CRC Press, Taylor & Francis Group, 2014.

Reference Books

1.	Azodolmolky, Siamak, "Software Defined Networking with OpenFlow", Packt Publishing Ltd., 2013.
2.	Nadeau, Thomas D., Ken Gray, "SDN: Software Defined Networks: An Authoritative Review of Network Programmability Technologies", O'Reilly Media Inc., 2013.
3.	Dillinger, Markus, Kambiz Madani, Nancy Alonistioti, "Software Defined Radio: Architectures, Systems and Functions", John Wiley & Sons, 2005.
4.	Goransson, Paul, Chuck Black, Timothy Culver, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, 2016.

Course Outcomes

At the end of the course student will be able

CO1	Comprehend Software Defined Networks
CO2	Design and implement software defined network
CO3	Design algorithm for virtualization
CO4	Design algorithm for big data analytics

Course Code	CSHO12
Course Title	Multi-Core Programming
Type of Course	Honours
Prerequisites	CSPC51
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of multi-core architecture
CLO2	To be able to know the basic concepts of multi core programming using threads
CLO3	To be able to understand various programming constructs in multi-core architecture
CLO4	To be able to understand Multithreaded applications

Course Content:

UNIT I Introduction to Multiprocessors and Scalability Issues

Scalable design principles - Principles of processor design - Instruction Level Parallelism - Thread level parallelism - Parallel computer models - Symmetric and distributed shared memory architectures - Performance Issues - Multi-core Architectures - Software and hardware multithreading - SMT and CMP architectures - Design issues - Case studies - Intel Multi-core architecture - SUN CMP architecture**.**

UNIT II Parallel Programming

Fundamental concepts - Designing for threads - scheduling - Threading and parallel programming constructs - Synchronization - Critical sections - Deadlock - Threading APIs.

UNIT III OpenMP Programming

OpenMP - Threading a loop - Thread overheads - Performance issues - Library functions - Solutions to parallel programming problems - Data races - deadlocks and livelocks - Non-blocking algorithms - Memory and cache related issues.

UNIT IV MPI Programming

MPI Model - collective communication - data decomposition - communicators and topologies - point-to-point communication - MPI Library.

UNIT V Multi Threaded Application Development

Algorithms - program development and performance tuning

Text Books:

1.Shameem Akhter, Jason Roberts, “Multi-core Programming”, Intel Press, 2006
2.Michael J Quinn, “Parallel programming in C with MPI and OpenMP”, Tata McGraw Hill, 2003

Reference Books:

1.	John L. Hennessey, David A. Patterson, “Computer Architecture – A Quantitative Approach”, Fourth Edition, Morgan Kaufmann/Elsevier Publishers, 2007.
2.	David E. Culler, Jaswinder Pal Singh, “Parallel Computing Architecture: A Hardware/Software Approach”, Morgan Kaufmann/Elsevier Publishers, 1999.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	To understand the limitations of ILP and the necessity of multi-core architecture
CO2	To be able to know the basic concepts of multi core programming to manage threads using the role of Open-MP
CO3	To be able to understand various programming constructs and Solve the issues related to multiprocessing and suggest solutions in multicore architecture and multithreaded application
CO4	To design scalable and high-performance software systems, which includes performance analysis, algorithmic techniques for high performance, instruction-level optimizations, caching optimizations, parallel programming, and building scalable systems

Course Code	CSHO13
Course Title	Pervasive and Ubiquitous Computing
Type of Course	HO
Prerequisites	CSPC43
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the characteristics and principles of Pervasive computing and to understand the various components that helps to build pervasive computing system
CLO2	To understand the necessity of sensor networks and RFID that capture and disseminate context information
CLO3	To understand the principles, challenges, infrastructures and user interface that supports the ubiquitous computing
CLO4	To design and implement Pervasive and Ubiquitous applications that are embedded in everyday objects

Course Content:

UNIT I Introduction

Pervasive Computing: Principles - Characteristics - interaction transparency - context aware - automated experience capture - Vision and challenges of pervasive computing - Pervasive computing infrastructure - Architecture for pervasive computing - Pervasive devices - embedded controls - smart sensors and actuators -Context communication and access services.

UNIT II Technologies

Device Technology for Pervasive Computing: Hardware - Human-machine interfaces - Biometrics - Operating Systems - Java for pervasive devices - Voice Technology: Basics of Speech Recognition - Voice standards - Speech Applications - Speech and Pervasive Computing - Security - Personal Digital Assistants.

UNIT III Sensor Networks and RFID

Introduction to Sensor networks: Sensor Node Architecture - Sensor Network Architecture - Types of sensor networks - Platforms for Wireless sensor networks - Applications of Wireless Sensor networks - Introduction to RFID - transponder and reader architecture - Types of tags and readers - Frequencies of operation - Application of RFID Technologies.

UNIT IV Introduction to Ubiquitous Computing

An introduction - overview - challenges to research topics in ubiquitous computing including sensors - ambient displays - tangibles - middleware - mobility - allocation and context awareness - Architecture for ubiquitous computing: new devices and communications - software architectures - Wireless standards & protocols for ubiquitous networks - Near field communication (NFC) - Bluetooth classic - Bluetooth Low Energy (BLE) - WiFi - WiFi Direct.

UNIT V Ubiquitous Computing Applications

Ubiquitous applications: the appropriate design - Weiser's vision of ubiquitous computing - mixed reality and sensible design - Wearable computing - Glass and Augmented Reality - Eye-Tracking-Digital Pen and Paper Mobile social networking & crowd sensing Event based social network.

Text Books:

1. Jochen Burkhardt, Horst Henn, Stefan Hepper, Thomas Schaec, Klaus Rindtorff, "Pervasive Computing: Technology and Architecture of Mobile Internet Applications", Sixth Edition, Pearson Education, New Delhi, 2009.
2. Seng Loke, "Context-Aware Computing Pervasive Systems", Auerbach Pub., Taylor and Francis Group, New York, 2007.
3. John Krumm, "Ubiquitous Computing Fundamentals", CRC Press, 2010.

Reference Books:

1.	Rahul Banerjee, "Lecture Notes in Pervasive Computing", Outline Notes, BITS-Pilani, 2012.
2.	Genco, S. Sorce, "Pervasive Systems and Ubiquitous Computing", WIT Press, 2012.
3.	Guruduth S. Banavar, Norman H. Cohen, Chandra Narayanaswami, "Pervasive Computing: An Application-Based Approach", Wiley Interscience, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamental theoretical concepts in pervasive computing
CO2	Conclude the enabling technologies that drive the pervasive and ubiquitous computing
CO3	Formulate the design aspects, that are essential to create the model of pervasive computing
CO4	Develop solutions for problems related to pervasive and ubiquitous computing system through investigation

Course Code	CSHO14
Course Title	Virtualization Techniques
Type of Course	HO
Prerequisites	-
Contact Hours	L-T-P-C : 3-0-0-3
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To explore the various virtualization principles that are to be implemented in a cloud environment
CLO2	To study about system virtualization
CLO3	To understand the fundamentals and necessity of Network and Storage virtualization
CLO4	To understand the vulnerabilities in virtualization and techniques for securing the virtualized environment.

UNIT I

INTRODUCTION TO VIRTUALIZATION Virtualization and cloud computing - Need of virtualization - cost, administration, fast deployment, reduce infrastructure cost - limitations - Types of hardware virtualization : Full virtualization - partial virtualization - Paravirtualization - Types of Hypervisors.

UNIT II

SERVER AND DESKTOP VIRTUALIZATION Virtual machine basics - Types of virtual machines - Understanding Server Virtualization - types of server virtualization - Business Cases for Server Virtualization - Uses of Virtual Server Consolidation - Selecting Server Virtualization Platform - Desktop Virtualization -Types of Desktop Virtualization.

UNIT III

NETWORK VIRTUALIZATION Introduction to Network Virtualization-Advantages - Functions - Tools for Network Virtualization - VLAN - WAN Architecture -WAN Virtualization.

UNIT IV

STORAGE VIRTUALIZATION Memory Virtualization -Types of Storage Virtualization - Block, File - Address space Remapping - Risks of Storage Virtualization-SAN-NAS-RAID.

UNIT V

VIRTUALIZATION Security – Fundamentals of Virtualization Security – Securing Hypervisors – Designing Virtual networks for security – comparing virtual and physical networks – Security recommendations for management platforms – virtual machine threats and vulnerabilities – logging and auditing.

Text Books:

1. Jochen Burkhardt, Horst Henn, Stefan Hepper, Thomas Schaec, Klaus Rindtorff, “Pervasive Computing: Technology and Architecture of Mobile Internet Applications”, Sixth Edition, Pearson Education, New Delhi, 2009.
2. Seng Loke, “Context-Aware Computing Pervasive Systems”, Auerbach Pub., Taylor and Francis Group, New York, 2007.
3. John Krumm, “Ubiquitous Computing Fundamentals”, CRC Press, 2010.

Reference Books:

1.	Zivko Bojovic, "Application of Network function virtualization in modern computer environments", Now Publishers, 2024
2.	Dave Shackleford, "Virtualization Security: Protecting Virtualized Environments", Sybex Publishers, 2012.
3.	Prasad Mukhedkar, "Mastering KVM Virtualization", Packt Publishing, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Suggest appropriate virtualization needs for an organization to maximize resource utilization
CO2	Design the virtualization needs for any given organization
CO3	Modify appropriate virtualization algorithms to suit any organization
CO4	Identify the vulnerabilities in the organizations' infrastructure and provide security algorithms for virtualized resources

Course Code	CSHO15
Course Title	Randomized Algorithms
Type of Course	HO
Prerequisites	CSPC42
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Objectives

CLO1	To introduce the concept of randomized algorithms
CLO2	To apply the concepts of probabilistic analysis of algorithms
CLO3	To derive good upper bounds for the expected running time of simple randomized algorithm
CLO4	To analyze the performance of randomized algorithms
CLO5	To design simple randomized algorithm that run faster or return correct output with high probability

Course Contents

UNIT I Probability and Computing

Elements of probability theory - Verification of strings - poly identities - matrix multiplication - Las Vegas and Monte Carlo algorithms - Expectations - Jensen's Inequality - Coupon collector's problem - geometric distribution.*

UNIT II Expectations, Moments and Inequalities

Randomized Quick Sort and its expected run-time - Variance and moments - Chebyshev's inequality - Coupon collector's problem - randomized median finding - analysis - moment generating functions.*

UNIT III Chernoff's Bounds and its Applications

Derivation and application of Chernoff's bounds - Sum of Poisson Trials - Coin flips - Set balancing - Packet routing in sparse networks - permutation routing on the hypercube - butterfly.*

UNIT IV Balls, Bins and Random Graphs

Birthday paradox - balls and bins model - application to bucket sort - Poisson distribution - Application to hashing - random graph models - Hamiltonian cycles in random graphs.*

UNIT V Markov Chains and Random Walks

Markov chains - representations - randomized algorithm for 2-satisfiability and 3-satisfiability - classification of states - gambler's ruin - random walks on undirected graphs - s-t connectivity algorithm.*

*Programming assignments are mandatory.

Text Book

1. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, by Mitzenmacher and Upfal, Cambridge University Press, 2nd edition, 2017.
2. Motwani and Raghavan, "Randomized Algorithms", Cambridge University Press, 1995

Reference Books

1. William Feller, " An introduction to Probability Theory and Its Applications, Volumes I and II, John Wiley, New York, 2009.
2. Dimitri P. Bertsekas and John N. Tsitsiklis, "Introduction To Probability", Athena Scientific, June 2008
3. Patrick Billingsley, "Probability and Measure", John Wiley and Sons,1986.

Course Outcomes

At the end of the course student will be able to

CO1	Learn the mathematical foundations emphasizing the design and analysis of randomized algorithm
CO2	Apply basics of probability theory in the analysis of algorithms
CO3	Comprehend randomized algorithms and its advantages to traditional algorithm
CO4	Design and implement randomized techniques in solving real world problems and analyze their performance

Course Code	CSHO16
Course Title	Compiler Optimization Techniques
Type of Course	HO
Prerequisites	CSPC41
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the need for optimizations in a compiler
CLO2	To explore and optimize the flow analysis
CLO3	To study the need and methods of dependence analysis
CLO4	To exploit the different optimizations in loops, procedures
CLO5	To understand the need for register allocation and memory optimizations

Course Content

UNIT-I Introduction

Phases of the compiler – Intermediate Representations – Symbol Tables – Procedure abstraction – Name Spaces – Managing memory – Storage locations – Storing and accessing arrays – Character Strings – Structure References – Control-flow constructs – Procedure calls – Introduction to optimization – Scope of Optimizations – Value numbering over regions larger than basic blocks – Global Redundancy elimination – Cloning – inline substitution

UNIT-II Control and Data flow analysis

Control flow analysis - Approaches – DFS, Preorder, Postorder and BFS – Dominators and postdominators – Loops and strongly connected components – reducibility – interval analysis and control trees – structural analysis – Data flow analysis – Taxonomy of dataflow problems and solutions – iterative data-flow analysis – lattices of flow functions – control tree based analysis - structural analysis – interval analysis – SSA form – Data flow analysers

UNIT-III Dependence analysis and early optimizations

Dependence relations – DAGs – Dependence in loops, testing, dynamically allocated objects – Aliases in Programming languages – aliases gatherer – alias propagator - Optimizations – Flow sensitivity early optimizations – Constant folding – scalar replacements – value numbering – cop propagations – redundancy elimination – partial-redundancy elimination – code hoisting

UNIT-IV Loop and Procedure Optimization

Induction-variable elimination – unnecessary bounds-check elimination – Tail-call optimization and tail recursion elimination – procedure integration – in-line expansion - leaf-routine optimization and shrink wrapping – If simplifications – Branch prediction – Branch optimization

UNIT-V Register and Memory optimization

Memory vs Registers – Allocation vs assignment – register classes – local register allocation and assignment - global register allocation and assignment – Impact of data and instruction cache – instruction-cache optimization – Data-cache optimization -

Text Books

1. EMC Education Services, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Wiley publishers, 2015.
2. Simon Walkowiak, “Big Data Analytics with R”, PackT Publishers, 2016.

Reference Books

1. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.
2. Kim H. Pries, Robert Dunnigan, "Big Data Analytics: A Practical Guide for Managers", CRC Press, 2015.

Course Outcomes

At the end of the course student will be able to

CO1	Implement stand-alone optimization techniques for some snippet of code
CO2	Comprehend the differences and similarities in the various approaches to optimizations
CO3	Design compilers for new languages by incorporating the necessary optimization techniques
CO4	Propose new algorithms of optimization by modifying the existing approaches

Course Code	CSHO17
Course Title	Fog and Edge Computing
Type of Course	PE
Prerequisites	-
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce Fog Computing technologies and its opportunities.
CLO2	To review underlying technologies, limitations, and challenges along with performance metrics and discuss generic conceptual framework in fog computing.
CLO3	To learn the techniques for storage and computation in fogs, edges, 5G and clouds.
CLO4	To impart the knowledge to log the sensor data and to perform further data analytics.
CLO5	Analyze the performance and issues of the applications developed using fog and edge architecture.

Course Content

Unit –I Introduction to Fog Computing
Introduction to Fog Computing, Limitation of Cloud Computing, Differences between Cloud and Fog Computing, Advantages, Business Models, Architecture, Opportunities and Challenges.

Unit –II Challenges in Fog Resources:
Taxonomy and Characteristics, Resource Management Challenge, Optimization Challenges, Miscellaneous Challenges.

Unit –III IoT and Fog
Programming Paradigms, Research Challenges and Research Directions, Fog Protocols, Management and Orchestration of Network Slices in 5G, Fog, Edge and Clouds, Data Management and Analysis in Fog Computing, Case Studies.

Unit –IV Introduction to Edge Computing
Origins of Edge, Edge Helping Low-End IoT Nodes, Architecture, Edge Helping Higher-Capability.

Unit –V Applications of Fog and Edge Computing
Mobile Offloading, Edge Helping the Cloud, Edge for Augmented Reality, Data Processing on the Edge, Dispersed Learning with Edge/Fog Computing, Video Analytics on the Edge, Edge Computing Applications.

Text Books

1. Buyya, Rajkumar, and Satish Narayana Srirama, Fog and Edge computing: Principles and Paradigms, 2019, 1st edition, John Wiley & Sons, USA.
2. Wei Change and Jie Wu, Fog/Edge Computing for Security, Privacy and Applications, Springer, 2021.

References

1.	Bahga, Arshdeep, and Vijay Madisetti, Cloud computing: A hands-on approach, 2014, 2ndedition, CreateSpace Independent Publishing Platform, USA.
2.	OvidiuVermesan, Peter Friess, "Internet of Things –From Research and Innovation to Market Deployment", 2014, 1st edition, River Publishers, India.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the key architectures and basic fundamentals of fog computing.
CO2	Understand the challenges in fog computing.
CO3	Perform fog and edge computing services.
CO4	Understand the basic fundamentals of edge computing and Use fog and edge computing services in various applications.

Course Code	CSHO18
Course Title	Quantum Safe Cryptography
Type of Course	HO
Prerequisites	CSPC63
Contact Hours	L-T-P-C : 3-1-0-4
Course Assessment Methods	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide basic concepts of Lattice based Cryptography
CLO2	To explain the impact of quantum computers on modern cryptography
CLO3	To introduce quantum cryptographic tools and protocols, and their cryptanalysis
CLO4	To comprehend the notion of provable security and its implication with improved security guarantees
CLO5	To provide basic concepts of Lattice based Cryptography

Course Content

UNIT I

Review of public key cryptography. Subset-sum problems and knapsack cryptosystems, Lattices: Basic definitions and properties, short vectors in lattices, Babai's algorithm, Cryptosystems based on hard lattice problems, The GGH public key cryptosystem

UNIT –II

Convolution polynomial rings, The NTRU public key cryptosystem, NTRU as a lattice cryptosystem. Lattice reduction algorithms, LLL algorithm. Applications of LLL to cryptanalysis.

UNIT III

Useful Lattice Problems: Learning with Errors (LWE), Short Integer Solution (SIS), Short Integer Solution (ISIS), Ring-LWE.

Public key cryptography from LWE, Public key cryptography from Ring-LWE, IND-CPA and IND-CCA security in lattice-based cryptography, Crystals – Kyber algorithm, Lattice based identity-based cryptosystem.

Unit IV

Lattice based hash function, Lattice based digital signature, CRYSTALS-Dilithium, and FALCON, Lattice based commitment scheme, Lattice based Zero Knowledge Proof.

UNIT V

Review of quantum computers, Quantum key distribution protocols: The BB84, E91. Quantum key agreement protocols, Quantum one time pad, Quantum public key encryption, Quantum oblivious transfer, Quantum money.

Text Books

1. Thomas Vidick , Stephanie Wehner, "Introduction to Quantum Cryptography", September 2023.
2. Jiang Zhang, Zhenfeng Zhang, "Lattice-Based Cryptosystems A Design Perspective" Springer, 2020.

References

1	Lecture notes on Lattice-based Cryptography by Daniele Micciancio & Oded Regev.
2	Lecture notes by Chris Peikert on "A Decade of Lattice Cryptography".
3	NPTEL course on "Quantum Algorithms and Cryptography" by Prof. Shweta Agarwal, IIT Madras.
4	Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman, "An Introduction to Mathematical Cryptography", Springer ,2008, ISBN: 978-0-387-77993-5.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify the difference between conventional and Lattice based cryptography protocols.
CO2	Ability to break the Lattice based Cryptosystem that is not secure.
CO3	Derive simple provable security proofs for Lattice based schemes and quantum protocols.
CO4	Design and implement quantum cryptographic protocols.