CURRICULUM FRAMEWORK AND SYLLABUS

FOR

FIVE YEAR INTEGRATED M.Sc. (DATA SCIENCE) DEGREE PROGRAMME

IN CHOICE BASED CREDIT SYSTEM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2023-2024 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Passed in Board of Studies meeting held on 19-04-2023 Approved in 65th Academic Council meeting on 27-05-2023

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI 625 015

DEPARTMENT OF APPLIED MATHEMATICS AND COMPUTATIONAL SCIENCE

VISION

"Academic and research excellence in Computational Science"

MISSION

As a Department, we are committed to

- Achieve academic excellence in Computational Science through innovative teachingand learning processes.
- Enable the students to be technically competent to solve the problems faced by theindustry.
- Create a platform for pursuing inter-disciplinary research among the faculty and thestudents to create state of art research facilities.
- Promote quality and professional ethics among the students.
- Help the students to learn entrepreneurial skills.

Programme Educational Objectives (PEO)

Post graduates of M.Sc.(Data Science) program will be

PEO1: Utilizing strong quantitative aptitude and domain knowledge to apply quantitative modeling and data analysis techniques to provide solutions to the real-world business problems.

PEO2: Applying research and entrepreneurial skills augmented with a rich set of communication, teamwork, and leadership skills to excel in their profession.

PEO3: Showing continuous improvement in their professional career through life-long learning, appreciating human values and ethics.

Programme Outcomes (PO) for M.Sc. (Data Science)

On completion of the programme, the students are expected to

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the

consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO) for M.Sc. Data Science

PSO1: To become a skilled Data Scientist in industry, academia, or government by independently carrying out research based statistical experiments to solve analytical problems following the ethics for data science

PSO2: To exhibit professional and interpersonal skills in data collection and its analysis using mathematical modelling and statistical techniques, querying and reporting for business and societal requirements using state-of-the-art tools.

PEO-PO & PSO Mapping:

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1														
2														
3														

Five Year Integrated M.Sc (Data Science) Degree Programme Curriculum

2023-2024 Onwards
CHOICE BASED CREDIT SYSTEM

Credit Distribution:

S. No.	Category of courses	Credits	Percentage of Credits To TotalCredits
1	Foundation Courses	50	23.70
2	Professional Core Courses- Theory	88	41.70
3	Professional Core Courses- Practical	28	13.27
4	Professional Elective Courses	15	7.11
5	Employability Enhancement Courses	30	14.22
	Total Credits	**211**	100%

Foundation courses (FC):

Course Code	Name Of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
23DS110	CALCULUS	FC	4	0	0	4
23DS120	FOUNDATIONS OF DATA SCIENCE	FC	4	0	0	4
23DS130	DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION	FC	4	0	0	4
23DS140	PROBLEM SOLVING USING C PROGRAMMING	FC	4	0	0	4
23DS150	DISCRETE STRUCTURES	FC	4	0	0	4
23DS170	C PROGRAMMING LAB	FC	0	0	4	2
23DS210	THEORY OF PROBABILITY	FC	4	0	0	4
23DS230	GRAPH THEORY	FC	4	0	0	4
23DS310	PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS	FC	4	0	0	4
23DS320	ABSTRACT ALGEBRA	FC	4	0	0	4
23DS410	LINEAR ALGEBRA	FC	4	0	0	4
23DS510	NUMERICAL METHODS	FC	4	0	0	4
23DS520	OPTIMIZATION TECHNIQUES	FC	4	0	0	4

Professional Core Courses (PCC):

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
23DS220	APPLIED STATISTICS	PCC	4	0	0	4
23DS240	OBJECT ORIENTED PROGRAMMING	PCC	4	0	0	4
23DS250	ORGANIZATIONAL THEORY AND BEHAVIOUR	PCC	3	0	0	3
23DS270	PYTHON PROGRAMMING AND APPLIED STATISTICS LAB	PCC	0	0	6	3
23DS280	OBJECT ORIENTED PROGRAMMING LAB	PCC	0	0	4	2
23DS330	DATA STRUCTURES	PCC	4	0	0	4
23DS340	DATABASE MANAGEMENT	PCC	4	0	0	4
23DS350	OPERATING SYSTEMS	PCC	3	0	0	3
23DS370	DATA STRUCTURES LAB	PCC	0	0	4	2
23DS380	RELATIONAL DATABASE LAB	PCC	0	0	4	2
23DS420	PREDICTIVE ANALYTICS	PCC	4	0	0	4
23DS430	DESIGN AND ANALYSIS OF ALGORITHMS	PCC	3	1	0	4
23DS440	ADVANCED DATA STRUCTURES	PCC	4	0	0	4
23DS450	SOFTWARE ENGINEERING	PCC	3	0	0	3
23DS470	PREDICTIVE ANALYTICS LAB	PCC	0	0	4	2
23DS480	JAVA PROGRAMMING LAB	PCC	0	0	6	3
23DS530	WEB TECHNOLOGY	PCC	4	0	0	4
23DS540	MACHINE LEARNING	PCC	4	0	0	4
23DS550	COMPUTER NETWORKS	PCC	4	0	0	4
23DS570	WEB TECHNOLOGY LAB	PCC	0	0	4	2
23DS610	DEEP LEARNING	PCC	4	0	0	4

23DS620	DATA MINING	PCC	4	0	0	4
23DS630	BIG DATA SYSTEMS	PCC	4	0	0	4
23DS640	ETHICS FOR DATA SCIENCE	PCC	3	0	0	3
23DS670	DEEP LEARNING LAB	PCC	0	0	4	2
23DS680	BIG DATABASE SYSTEMS LAB	PCC	0	0	4	2
23DS810	REINFORCEMENT LEARNING	PCC	4	0	0	4
23DS820	DATA VISUALIZATION	PCC	4	0	0	4
23DS830	BUSINESS ANALYTICS	PCC	3	1	0	4
23DS870	MATHEMATICAL COMPUTING LAB	PCC	0	0	4	2
23DS880	BUSINESS ANALYTICS AND VISUALIZATION LAB	PCC	0	0	4	2
23DS910	WEB ANALYTICS	PCC	4	0	0	4
23DS920	NATURAL LANGUAGE PROCESSING	PCC	4	0	0	4
23DS930	COMPUTER VISION	PCC	3	1	0	4
23DS970	WEB ANALYTICS LAB	PCC	0	0	4	2
23DS980	NATURAL LANGUAGE PROCESSING LAB	PCC	0	0	4	2

Professional Elective Courses (PEC):

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
23DSPA0	HIGH PERFORMANCE COMPUTING	PEC	3	0	0	3
23DSPB0	MOBILE APPLICATION DEVELOPMENT	PEC	3	0	0	3
23DSPC0	HEALTHCARE INFORMATICS	PEC	3	0	0	3
23DSPD0	EMBEDDED SYSTEM	PEC	3	0	0	3
23DSPE0	MARKETING ANALYTICS	PEC	3	0	0	3
23DSPF0	LARGE LANGUAGE MODELS	PEC	3	0	0	3
23DSPG0	SOFT COMPUTING	PEC	3	0	0	3
23DSPH0	MATHEMATICAL MODELING	PEC	3	0	0	3
23DSPJ0	GRAPH ALGORITHMS	PEC	3	0	0	3

23DSPK0	EXPLAINABLE ARTIFICIAL INTELLIGENCE	PEC	3	0	0	3
23DSPL0	GAME THEORY	PEC	3	0	0	3
23DSPM0	SOCIAL MEDIA ANALYTICS	PEC	3	0	0	3
23DSPN0	CLOUD COMPUTING	PEC	3	0	0	3
23DSPP0	INTERNET OF THINGS AND DATA ANALYTICS	PEC	3	0	0	3
23DSPQ0	COMPUTATIONAL FINANCE	PEC	3	0	0	3
23DSPR0	ENTERPRISE INFORMATION SYSTEM	PEC	3	0	0	3
23DSPS0	RANDOMIZED ALGORITHMS	PEC	3	0	0	3
23DSPT0	PRINCIPLES OF MANAGEMENT	PEC	3	0	0	3
23DSPU0	ACCOUNTING AND FINANCIAL MANAGEMENT	PEC	3	0	0	3
23DSPV0	WIRELESS NETWORKS	PEC	3	0	0	3
23DSPW0	NETWORK SCIENCE	PEC	3	0	0	3
23DSPX0	INFORMATION RETRIEVAL	PEC	3	0	0	3

Employability Enhancement Courses (EEC):

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
23DS180	PROFESSIONAL ENGLISH	EEC	0	2	2	3
23DS580	MINI PROJECT	EEC	0	0	6	3
23DSP10	PROJECT WORK I	EEC	0	0	24	12
23DSP20	PROJECT WORK II	EEC	0	0	24	12

Thiagarajar College of Engineering, Madurai – 625 015
Department of Applied Mathematics and Computational Science
Five Year Integrated M.Sc (Data Science) Degree Programme [2023-2024 onwards]
Scheduling of Courses

Sem-ester	Theory					Practical		Credits
1	23DS110 CALCULUS 4:0	23DS120 FOUNDATIONS OF DATA SCIENCE 4:0	23DS130 DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION 4:0	23DS140 PROBLEM SOLVING USING C PROGRAMMING 4:0	23DS150 DISCRETE STRUCTURES 4:0	23DS170 C PROGRAMMING LAB 0:2	23DS180 PROFESSIONAL ENGLISH 0:3	25
2	23DS210 THEORY OF PROBABILITY 4:0	23DS220 APPLIED STATISTICS 4:0	23DS230 GRAPH THEORY 4:0	23DS240 OBJECT ORIENTED PROGRAMMING 4:0	23DS250 ORGANIZATIONAL THEORY AND BEHAVIOR 3:0	23DS270 PYTHON PROGRAMMING AND APPLIED STATISTICS LAB 0:3	23DS280 OBJECT ORIENTED PROGRAMMING LAB 0:2	24
3	23DS310 PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS 4:0	23DS320 ABSTRACT ALGEBRA 4:0	23DS330 DATA STRUCTURES 4:0	23DS340 DATABASE MANAGEMENT 4:0	23DS350 OPERATING SYSTEMS 3:0	23DS370 DATA STRUCTURES LAB 0:2	23DS380 RELATIONAL DATABASE LAB 0:2	23
4	23DS410 LINEAR ALGEBRA 4:0	23DS420 PREDICTIVE ANALYTICS 4:0	23DS430 DESIGN AND ANALYSIS OF ALGORITHMS 3:1	23DS440 ADVANCED DATA STRUCTURES 4:0	23DS450 SOFTWARE ENGINEERING 3:0	23DS470 PREDICTIVE ANALYTICS LAB 0:2	23DS480 JAVA PROGRAMMING LAB 0:3	24
5	23DS510 NUMERICAL METHODS 4:0	23DS520 OPTIMIZATION TECHNIQUES 4:0	23DS530 WEB TECHNOLOGY 4:0	23DS540 MACHINE LEARNING 4:0	23DS550 COMPUTER NETWORKS 4:0	23DS570 WEB TECHNOLOGY LAB 0:2	23DS580 MINI PROJECT 0:3	25
6	23DS610 DEEP LEARNING 4:0	23DS620 DATA MINING 4:0	23DS630 BIG DATA SYSTEMS 4:0	23DS640 ETHICS FOR DATA SCIENCE 3:0	23DSPX0 PROFESSIONAL ELECTIVE I 3:0	23DS670 DEEP LEARNING LAB 0:2	23DS680 BIG DATABASE SYSTEMS LAB 0:2	22
7	23DSP10 PROJECT WORK I - 0:12							12
8	23DS810 REINFORCEMENT LEARNING 4:0	23DS820 DATA VISUALIZATION 4:0	23DS830 BUSINESS ANALYTICS 3:1	23DSPX0 PROFESSIONAL ELECTIVE-II 3:0	23DSPX0 PROFESSIONAL ELECTIVE-III 3:0	23DS870 MATHEMATICAL COMPUTING LAB 0:2	23DS880 BUSINESS ANALYTICS AND VISUALIZATION LAB 0:2	22
9	23DS910 WEB ANALYTICS 4:0	23DS920 NATURAL LANGUAGE PROCESSING 4:0	23DS930 COMPUTER VISION 3:1	23DSPX0 PROFESSIONAL ELECTIVE – IV 3:0	23DSPX0 PROFESSIONAL ELECTIVE – V 3:0	23DS970 WEB ANALYTICS LAB 0:2	23DS980 NATURAL LANGUAGE PROCESSING LAB 0:2	22
10	23DSP20 PROJECT WORK II - 0:12							12
							Total Credits	211

Passed in Board of Studies meeting held on 19-04-2023

Approved in 65th Academic Council meeting on 27-05-2023

Thiagarajar College of Engineering, Madurai

Five year Integrated M.Sc (Data Science) Degree Programme [2023-2024] onwards

Choice Based Credit System

Courses of Study

FIRST SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS110	CALCULUS	FC	4	-	-	4
23DS120	FOUNDATIONS OF DATA SCIENCE	FC	4	-	-	4
23DS130	DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION	FC	4	-	-	4
23DS140	PROBLEM SOLVING USING C PROGRAMMING	FC	4	-	-	4
23DS150	DISCRETE STRUCTURES	FC	4	-	-	4
PRACTICAL						
23DS170	C PROGRAMMING LAB	FC	-	-	4	2
23DS180	PROFESSIONAL ENGLISH	EEC	-	2	2	3
		TOTAL	20	2	6	25

SECOND SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS210	THEORY OF PROBABILITY	FC	4	-	-	4
23DS220	APPLIED STATISTICS	PCC	4	-	-	4
23DS230	GRAPH THEORY	FC	4	-	-	4
23DS240	OBJECT ORIENTED PROGRAMMING	PCC	4	-	-	4
23DS250	ORGANIZATIONAL THEORY AND BEHAVIOUR	PCC	3	-	-	3
PRACTICAL						
23DS270	PYTHON PROGRAMMING AND APPLIED STATISTICS LAB	PCC	-	-	6	3
23DS280	OBJECT ORIENTED PROGRAMMING LAB	PCC	-	-	4	2
		TOTAL	19	-	10	24

THIRD SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS310	PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS	FC	4	-	-	4
23DS320	ABSTRACT ALGEBRA	FC	4	-	-	4
23DS330	DATA STRUCTURES	PCC	4	-	-	4
23DS340	DATABASE MANAGEMENT	PCC	4	-	-	4
23DS350	OPERATING SYSTEMS	PCC	3	-	-	3
PRACTICAL						
23DS370	DATA STRUCTURES LAB	PCC	-	-	4	2
23DS380	RELATIONAL DATABASE LAB	PCC	-	-	4	2
		TOTAL	19	-	8	23

FOURTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS410	LINEAR ALGEBRA	FC	4	-	-	4
23DS420	PREDICTIVE ANALYTICS	PCC	4	-	-	4
23DS430	DESIGN AND ANALYSIS OF ALGORITHMS	PCC	3	1	-	4
23DS440	ADVANCED DATA STRUCTURES	PCC	4	-	-	4
23DS450	SOFTWARE ENGINEERING	PCC	3	-	-	3
PRACTICAL						
23DS470	PREDICTIVE ANALYTICS LAB	PCC	-	-	4	2
23DS480	JAVA PROGRAMMING LAB	PCC	-	-	6	3
		TOTAL	18	1	10	24

FIFTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS510	NUMERICAL METHODS	FC	4	-	-	4
23DS520	OPTIMIZATION TECHNIQUES	FC	4	-	-	4
23DS530	WEB TECHNOLOGY	PCC	4	-	-	4
23DS540	MACHINE LEARNING	PCC	4	-	-	4
23DS550	COMPUTER NETWORKS	PCC	4	-	-	4
PRACTICAL						
23DS570	WEB TECHNOLOGY LAB	PC	-	-	4	2
23DS580	MINI PROJECT	EEC	-	-	6	3
		TOTAL	20	-	10	25

SIXTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS610	DEEP LEARNING	PCC	4	-	-	4
23DS620	DATA MINING	PCC	4	-	-	4
23DS630	BIG DATA SYSTEMS	PCC	4	-	-	4
23DS640	ETHICS FOR DATA SCIENCE	PCC	3	-	-	3
23DSPX0	PROFESSIONAL ELECTIVE I	PEC	3	-	-	3
PRACTICAL						
23DS670	DEEP LEARNING LAB	PCC	-	-	4	2
23DS680	BIG DATABASE SYSTEMS LAB	PCC	-	-	4	2
		TOTAL	18	-	8	22

SEVENTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
23DSP10	PROJECT WORK – I	EEC	-	-	24	12
		TOTAL	-	-	24	12

EIGHTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS810	REINFORCEMENT LEARNING	PCC	4		-	4
23DS820	DATA VISUALIZATION	PCC	4	-	-	4
23DS830	BUSINESS ANALYTICS	PCC	3	1	-	4
23DSPX0	PROFESSIONAL ELECTIVE-II	PEC	3	-	-	3
23DSPX0	PROFESSIONAL ELECTIVE-III	PEC	3	-	-	3
PRACTICAL						
23DS870	MATHEMATICAL COMPUTING LAB	PCC	-	-	4	2
23DS880	BUSINESS ANALYTICS AND VISUALIZATION LAB	PCC	-	-	4	2
		TOTAL	17	1	8	22

NINTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
23DS910	WEB ANALYTICS	PCC	4	-	-	4
23DS920	NATURAL LANGUAGE PROCESSING	PCC	4	-	-	4
23DS930	COMPUTER VISION	PCC	3	1	-	4
23DSPX0	PROFESSIONAL ELECTIVE – IV	PEC	3	-	-	3
23DSPX0	PROFESSIONAL ELECTIVE – V	PEC	3	-	-	3
PRACTICAL						
23DS970	WEB ANALYTICS LAB	PCC	-	-	4	2
23DS980	NATURAL LANGUAGE PROCESSING LAB	PCC	-	-	4	2
		TOTAL	17	1	8	22

TENTH SEMESTER

Course code	Course Title	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
23DSP20	PROJECT WORK - II	EEC	-	-	24	12
		TOTAL	-	-	24	12

FC : Foundation Course
PCC : Professional Core Course
PEC : Professional Elective Course
EEC : Employability Enhancement Course

L : Lecture
T : Tutorial
P : Practical

Note:

- **1 Hour Lecture/week is equivalent to 1 credit**
- **1 Hour Tutorial/week is equivalent to 1 credit**
- **2 Hour Practical/week is equivalent to 1 credit**
- **Total credits to be earned for the award of degree: 211**

Thiagarajar College of Engineering, Madurai

Five year Integrated M.Sc (Data Science) Degree Programme

SCHEME OF EXAMINATIONS
(For Students admitted in the Academic Year 2023-2024 onwards)

FIRST SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS110	CALCULUS	3	40	60	100	27	50
23DS120	FOUNDATIONS OF DATA SCIENCE	3	40	60	100	27	50
23DS130	DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION	3	40	60	100	27	50
23DS140	PROBLEM SOLVING USING C PROGRAMMING	3	40	60	100	27	50
23DS150	DISCRETE STRUCTURES	3	40	60	100	27	50
PRACTICAL							
23DS170	C PROGRAMMING LAB	3	60	40	100	18	50
23DS180	PROFESSIONAL ENGLISH	3	60	40	100	18	50

SECOND SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS210	THEORY OF PROBABILITY	3	40	60	100	27	50
23DS220	APPLIED STATISTICS	3	40	60	100	27	50
23DS230	GRAPH THEORY	3	40	60	100	27	50
23DS240	OBJECT ORIENTED PROGRAMMING	3	40	60	100	27	50
23DS250	ORGANIZATIONAL THEORY AND BEHAVIOUR	3	40	60	100	27	50
PRACTICAL							
23DS270	PYTHON PROGRAMMING AND APPLIED STATISTICS LAB	3	60	40	100	18	50
23DS280	OBJECT ORIENTED PROGRAMMING LAB	3	60	40	100	18	50

THIRD SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS310	PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS	3	40	60	100	27	50
23DS320	ABSTRACT ALGEBRA	3	40	60	100	27	50
23DS330	DATA STRUCTURES	3	40	60	100	27	50
23DS340	DATABASE MANAGEMENT	3	40	60	100	27	50
23DS350	OPERATING SYSTEMS	3	40	60	100	27	50
PRACTICAL							
23DS370	DATA STRUCTURES LAB	3	60	40	100	18	50
23DS380	RELATIONAL DATABASE LAB	3	60	40	100	18	50

FOURTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS410	LINEAR ALGEBRA	3	40	60	100	27	50
23DS420	PREDICTIVE ANALYTICS	3	40	60	100	27	50
23DS430	DESIGN AND ANALYSIS OFALGORITHMS	3	40	60	100	27	50
23DS440	ADVANCED DATA STRUCTURES	3	40	60	100	27	50
23DS450	SOFTWARE ENGINEERING	3	40	60	100	27	50
PRACTICAL							
23DS470	PREDICTIVE ANALYTICS LAB	3	60	40	100	18	50
23DS480	JAVA PROGRAMMING LAB	3	60	40	100	18	50

FIFTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS510	NUMERICAL METHODS	3	40	60	100	27	50
23DS520	OPTIMIZATION TECHNIQUES	3	40	60	100	27	50
23DS530	WEB TECHNOLOGY	3	40	60	100	27	50
23DS540	MACHINE LEARNING	3	40	60	100	27	50
23DS550	COMPUTER NETWORKS	3	40	60	100	27	50
PRACTICAL							
23DS570	WEB TECHNOLOGY LAB	3	60	40	100	18	50
23DS580	MINI PROJECT	-	50	50	100	25	50

SIXTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS610	DEEP LEARNING	3	40	60	100	27	50
23DS620	DATA MINING	3	40	60	100	27	50
23DS630	BIG DATA SYSTEMS	3	40	60	100	27	50
23DS640	ETHICS FOR DATA SCIENCE	3	40	60	100	27	50
23DSPX0	PROFESSIONAL ELECTIVE I	3	40	60	100	27	50
PRACTICAL							
23DS670	DEEP LEARNING LAB	3	60	40	100	18	50
23DS680	BIG DATABASE SYSTEMS LAB	3	60	40	100	18	50

SEVENTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PROJECT WORK I							
23DSP10	PROJECT WORK - I	-	150	150	300	75	150

EIGHTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS810	REINFORCEMENT LEARNING	3	40	60	100	27	50
23DS820	DATA VISUALIZATION	3	40	60	100	27	50
23DS830	BUSINESS ANALYTICS	3	40	60	100	27	50
23DSPX0	PROFESSIONAL ELECTIVE-II	3	40	60	100	27	50
23DSPX0	PROFESSIONAL ELECTIVE-III	3	40	60	100	27	50
PRACTICAL							
23DS870	MATHEMATICAL COMPUTING LAB	3	60	40	100	18	50
23DS880	BUSINESS ANALYTICS AND VISUALIZATION LAB	3	60	40	100	18	50

NINTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY							
23DS910	WEB ANALYTICS	3	40	60	100	27	50
23DS920	NATURAL LANGUAGE PROCESSING	3	40	60	100	27	50
23DS930	COMPUTER VISION	3	40	60	100	27	50
23DSPX0	PROFESSIONAL ELECTIVE – IV	3	40	60	100	27	50
23DSPX0	PROFESSIONAL ELECTIVE – V	3	40	60	100	27	50
PRACTICAL							
23DS970	WEB ANALYTICS LAB	3	60	40	100	18	50
23DS980	NATURAL LANGUAGE PROCESSING LAB	3	60	40	100	18	50

TENTH SEMESTER

Course code	Course Title	Duration of Terminal Exam. in Hrs.	MARKS			Minimum Marks for Pass	
			Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PROJECT WORK II							
23DSP20	PROJECT WORK - II	-	150	150	300	75	150

*** Continuous Assessment (CA) evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The Department will put a process in place to ensure that the actual test paper follows the declared pattern.**

**** Terminal Examination for theory courses will be conducted for a maximum mark of 100 and subsequently be reduced to 60 marks for the award of terminal examination marks.**

**** Terminal Examination for laboratory courses will be conducted for a maximum mark of 100 and subsequently be reduced to 40 marks for the award of terminal examination marks**

**** Terminal viva voce for Mini Project will be conducted for a maximum mark of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks**

**** Terminal viva voce for Project work I and II will be conducted for a maximum mark of 300 and subsequently be reduced to 150 marks for the award of terminal examination marks**

		Category	L	T	P	Credits
23DS110	**CALCULUS**	FC	4	0	0	4

Preamble

This course will enable students to analyse the behaviour of functions of single and multi-variables to solve complex engineering problems, applications of multiple integrals in various real-life problems. Also, the students will learn the nature of the sequence and series in the technical problems.

Prerequisite

Nil

Course Outcomes

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

CO1	Explain the concept of Differentiation and Integration	Understand
CO2	Apply the concepts of maxima and minima for a given function with several variables, through finding stationary points and Lagrangian multiplier method for finding Maxima and Minima of a constrained problem.	Apply
CO3	Apply the suitable method to solve second and higher order Differential equations.	Apply
CO4	Apply integration concept and double integral over general Areas	Apply
CO5	Apply integration concept and triple integral over general volumes to find mass and moments.	Apply
CO6	Apply sequences and Series in the problems involving Science and Engineering with the knowledge of convergence and divergence of series using different tests.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	M	-	-	-	-	-	-	-	L	L	M
CO2	S	S	M	M	-	-	-	-	-	-	-	M	L	S
CO3	S	S	M	M	L	-	-	-	-	-	-	M	L	S
CO4	S	S	M	S	L	-	-	-	-	-	-	M	L	S
CO5	S	S	M	S	L	-	-	-	-	-	-	M	L	S
CO6	S	S	L	L	-	-	-	-	-	-	-	L	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	20																							2	10	-			
CO2	5	10	30						50																2	-	20			
CO3			30						50																2	5	10			
CO4													5	10	20						30				2	-	10			
CO5													5	10	20						40				-	-	20			
CO6														10	20						30				2	5	10			
Total (in %)	100						100						100						100						100					

Syllabus

LIMITS AND CONTINUITY: Differentiation **-** Function of single variable – Limit, continuity, periodic. Integration - Absolutely integral, fundamental theorem of calculus.

FUNCTIONS OF TWO VARIABLES: Partial derivative, total derivatives. Taylor series about a point. Stationary points – maxima, minima and saddle points. Constrained maxima and minima – Lagrange's multipliers method.

ORDINARY DIFFERENTIAL EQUATIONS: Linear Differential Equations of first order - Exact differential equations, Integrating factors, Bernoulli equations. Linear Differential Equations of second and higher order with constant coefficients and variable coefficients – Euler's and Legendre's type. Simultaneous equations with constant Co-efficient, Method of variation of parameters.

MULTIPLE INTEGRALS: Double integrals in Cartesian form - Change of order of integration – Double integrals in polar form. Triple integrals in Cartesian form, Change of variable in triple integrals into polar, spherical and cylindrical co-ordinates. Applications of multiple integrals.

SEQUENCES AND SERIES: Infinite Sequences – convergence, divergence. Infinite Series – convergence and divergence, comparison test, integral test, ratio test, root test. Alternating series – alternating series test, absolute and conditional convergence, Power series.

Reference Books and Web Resources:

1. Hass M. D. J., Giordano Weir F.R., "Thomas Calculus", Pearson Education,14th edition, 2018.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2014.
3. Lian, Hungerford, and Holcomb "Mathematics with Applications", Addison Wesley, 2010.
4. Michael D. Greenberg, "Advanced Engineering Mathematics", Pearson Education, 2013.
5. http://calculus.org
6. https://www.khanacademy.org/math/calculus-1
7. https://dlmf.nist.gov
8. https://www.siam.org/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Limits and Continuity**	
1.1	Differentiation **-** Function of single variable	2
1.2	Limit, continuity, periodic functions.	2
1.3	Integration – Absolutely integral, fundamental theorem of calculus.	2
2	**Functions of Two Variables**	
2.1	Partial derivative, total derivatives, Taylor series about a point.	2

Module No.	Topic	No. of Periods
2.2	Stationary points – maxima, minima and saddle points.	2
2.3	Constrained maxima and minima – Lagrange's multipliers method.	2
3	**Ordinary Differential Equations**	
3.1	Linear Differential Equations of first order - Exact differential equations, Integrating factors, Bernoulli equations.	2
3.2	Linear Differential Equations of second and higher order with constant coefficients and variable coefficients	2
3.3	Euler's and Legendre's type.	2
3.4	Simultaneous equations with constant Co-efficient, Method of variation of parameters.	2
4	**Multiple Integrals: Double Integrals**	
4.1	Double integrals in Cartesian form – Problems.	3
4.2	Change of order of integration - Problems.	2
4.3	Double integrals in polar form – Problems.	2
4.4	Triple integrals in Cartesian form – Problems.	3
4.5	Change of variable in triple integrals into polar – Problems.	2
4.6	Spherical and cylindrical co-ordinates. Applications of multiple integrals– Problems.	3
5	**Sequences and Series**	
5.1	Infinite Sequences – convergence, divergence.	3
5.2	Infinite Series – convergence and divergence, comparison test, integral test, ratio test, root test.	3
5.3	Alternating series – alternating series test, absolute and conditional convergence, and Power series.	3
	Total	44

Course Designer(s):

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Dept. of Applied Mathematics and Computational Science

23DS120	FOUNDATIONS OF DATA SCIENCE	Category	L	T	P	Credit
		FC	4	0	0	4

Preamble

Data science is an interdisciplinary field that draws on skills from mathematics, computer science, and statistics. This course will enable students to learn the fundamental concepts circumventing data science, and its applications.

Prerequisite

NIL

Course Outcomes

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

CO1	Describe the taxonomy of Data	Understand
CO2	Explore the current practices in Data Analytics	Understand
CO3	Identify the key roles for the Data Ecosystem	Understand
CO4	Identify the key roles for a successful analytics project	Understand
CO5	Apply the Data Analytics Life Cycle components to data science projects.	Apply
CO6	Apply data preparation and modelling techniques to data science related problem specifications.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	L
CO2	M	L	-	-	-	-	-	-	-	-	-	-	M	L
CO3	M	L	-	-	-	-	-	-	-	-	-	-	M	L
CO4	M	L	M	-	-	-	-	-	-	-		-	M	L
CO5	S	S	M	-	-	-	-	-	-	-	-	-	M	L
CO6	S	S	L	-	-	-	-	-	-	-	-	-	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	20																							4	10				
CO2	10	25						50																	4	10				
CO3	15	25						50																	4	10				
CO4													10	10											4	10				
CO5													5	10	20						50				2		20			
CO6													5	10	30						50				2		20			
Total (in %)	100						100						100						100						100					

Syllabus

Taxonomy of Data: Basics of Data Structures **-** Overview of Big Data –Introduction to analytics - Data Repositories.

State of the Practice in Analytics- BI versus Data science, Current Analytical Architecture, Drivers of Big Data, Emerging big data ecosystem and new approach to analytics.

Key Roles for the New Big Data Ecosystem- Deep Analytical Talent, Data Savvy Professional, Technology and Data Enablers, Data Scientist, Examples of Big Data Analytics.

Data Analytics- Overview - Analytics in a Data Science Project - Key roles for a successful analytics project.

Data Analytics Life Cycle (DALC) – Overview- Different phases in a DALC **- Phase I Discovery**- Learning the Business Domain, Resources, Framing the Problem, Identifying key stakeholders, Interviewing the Analytics Sponsor, Developing initial hypotheses, Identifying potential data Sources.

Phase II-Data Preparation- Preparing the analytic Sandbox, Performing ETLT, Learning about the data, Data conditioning, Survey and Visualize data using common tools for the Data Visualization Phase.

Phase III-Model Planning- Data exploration and variable selection, Model selection, Common tools for the model planning phase.

Phase IV-Model Building- Common tools for the model building phase, **Phase V-Communicate Results, Phase VI-Operationalize.**

Case Studies on Applications of Data Science and Data Analytics

Reference Books

1. Wiley., Dietrich, D., Heller, B., & Yang, B, “Data science & big data analytics: discovering, analyzing, visualizing and presenting data”, Wiley, First Edition, 2015.

2. Eliot P. Rezno, “Big Data: A Beginner's Guide to Using Data Science for Business”, CreateSpace Independent Publishing Platform, 2017.

3. Fahl, J, “Data Analytics: A Practical Guide To Data Analytics For Business, Beginner To Expert” , CreateSpace Independent Publishing Platform , 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Taxonomy of Data**	1
1.1	Basics of Data Structures	1
1.2	Overview of Big Data	1
1.3	Introduction to analytics	1
1.4	Data Repositories	1

Module No.	Topic	No. of Periods
2	**State of the Practice in Analytics**	
2.1	BI versus Data science	1
2.2	Current Analytical Architecture	2
2.3	Drivers of Big Data	1
2.4	Emerging big data ecosystem and new approach to analytics	2
3	**Key Roles for the New Big Data Ecosystem**	
3.1	Deep Analytical Talent	2
3.2	Data Savvy Professional	1
3.3	Technology and Data Enablers	1
3.4	Data Scientist	1
3.5	Examples of Big Data Analytics	1
4	**Data Analytics**	
4.1	Overview	1
4.2	Analytics in a Data Science Project	1
4.3	Key roles for a successful analytics project	1
5	**Data Analytics Life Cycle (DALC)**	
5.1	Overview	1
5.2	Different phases in a DALC	1
6	**Phase I Discovery**	1
6.1	Resources	1
6.2	Framing the Problem	1
6.3	Identifying key stakeholders	1
6.4	Interviewing the Analytics Sponsor	1
6.5	Developing initial hypotheses	1
6.6	Identifying potential data Sources	1
7	**Phase II-Data Preparation**	1
7.1	Preparing the analytic Sandbox	1
7.2	Performing ETLT	1
7.3	Learning about the data, Data conditioning	2

Module No.	Topic	No. of Periods
7.4	Survey and Visualize data using common tools for the Data Visualization Phase.	2
8	**Phase III-Model Planning**	1
8.1	Data exploration and variable selection	2
8.2	Model selection	1
8.3	Common tools for the model planning phase	1
9	**Phase IV-Model Building**	1
9.1	Common tools for the model building phase	1
10	**Phase V-Communicate Results,**	2
11	**Phase VI-Operationalize.**	2
12	**Case Studies on Applications of Data Science and Data Analytics**	2
	Total	**45**

Course Designer(s):

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		Category	L	T	P	Credit
23DS130	**DIGITAL ELECTRONICS AND COMPUTER ORGANIZATION**	FC	4	0	0	4

Preamble

This course will enable students to focus on the design and analysis of electronic circuits, understand the computer hardware and software components, their interactions and perform various computational tasks.

Prerequisite

Nil

Course Outcomes

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

CO1	Summarize the aspects of digital electronics in the design of simple and advanced computer architectures	Understand
CO2	Design combinational and sequential logic circuits, including adders, subtractors, encoders, decoders, multiplexers, de-multiplexers, flip-flops, counters, and shift registers.	Apply
CO3	Implement number systems and codes with appropriate number representations to perform arithmetic operations	Apply
CO4	Apply fundamental concepts of digital logic design in implementing Arithmetic and Logic unit	Apply
CO5	Demonstrate the design of control unit with micro instructions	Apply
CO6	Design input/output organizations using interrupts, DMA to fetch instructions in memory	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO2	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO3	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO4	S	M	M	-	-	-	-	-	-	-	-	-	L	L
CO5	S	M	L	-	-	-	-	-	-	-	-	-	L	L
CO6	S	M	L	-	-	-	-	-	-	-	-	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	20												10											2					
CO2	5	10	30						50																2		5			
CO3		10	20						50																2	5	20			
CO4													5	10	20						30				2	5	15			
CO5													5	10	15						40				2	5	20			
CO6														10	15						30					5	10			
Total (in %)	100						100						100						100						100					

Syllabus

DIGITAL SYSTEMS:

Number Systems and Codes:

Binary, Hexadecimal, Octal, BCD, 2421, Excess – 3, Gray

Digital Circuits and Gates:

Logical gates,TTL and MOS logic circuits

Combinational Logic:

Design and implementation of Half and Full adders, Encoders and decoders, Multiplexers and De-multiplexers

Sequential Logic:

R-S, J-K, and D Type Flip-Flops,Moore/Mealy models

Binary counters:

Ripple and synchronous types, Shift registers

COMPUTER ORGANIZATION

Functional Units and Bus Structures

Basic operational concepts, Bus structures

Machine Instructions and Addressing Modes -Machine instructions, Addressing modes

Arithmetic Operations- Number representations, operations of signed numbers, Addition, Multiplication and division operation

Processing Unit and ALU -Concepts of processing unit, Execution of complete instruction, Multi bus organization, Arithmetic and Logic Unit (ALU)- Adders, Fast adders, Multiplication and Division circuits

Control Unit – Control units type, Hardwired control, Microprogrammed - Micro instructions, Micro program sequencing, Micro instructions types

Memory: Memory units, memory types - efficiency

Input and Output Organization -Accessing I/O devices,Interrupts,Direct Memory Access (DMA),Interface circuits

Advanced Processor Architecture- RISC,Pipelining,Super scalar processors,VLIW,Parallel and vector processors

Reference Books

1. Leach D.P., “Digital Principles & Application”, Tata McGraw Hill, 2014.
2. William Stallings, “Computer Organization and Architecture”, Eleventh Edition, Pearson Education, 2022.
3. Carl Hamacher, Zvonko Vranesic, safwat Zaky, “Computer Organization and Embedded System”, Sixth Edition, Tata McGraw Hill, 2022.
4. David A. Patterson, John L.Hennessy, “Computer Organization and Design”, Fourth Edition, Morgan Kauffmann Publishers, 2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Digital Systems - Introduction**	
1.1	Fundamental aspects of semiconductors	1
2	**Number Systems and Codes**	
2.1	Binary	1
2.2	Hexadecimal	1
2.3	BCD, Gray, Excess-3, 2421	1
3	**Digital Circuits ,Gates and Combinational Logic:**	
3.1	AND, OR, NOT gates	2
3.2	TTL and MOS logic circuits	2
3.3	Design and implementation of Half and Full adders	1
3.4	Encoders and decoders	1
3.5	Multiplexers and De-multiplexers	1
4	**Sequential Logic**	
4.1	R-S, J-K, and D type Flip-Flops	1
4.2	Binary counters: Ripple and synchronous types	1
4.3	Shift registers	1
5	**Computer architecture**	
5.1	Basic operational concepts and functional units	1
5.2	Bus structures	1
5.3	Machine instructions	1
5.4	Addressing modes	1
6	**Design of ALU**	
6.1	Number representations	1
6.2	Addition and subtraction of signed numbers	1
6.3	Design of fast adders	1
6.4	Multiplication of signed numbers	1
6.5	Fast multiplication	1
6.6	Integer division	1

Module No.	Topic	No. of Periods
6.7	Concepts of processing unit	1
6.8	Execution of complete instruction	1
6.9	Multi bus organization	1
7	**Control Unit and Memory**	
7.1	Hardwired control	1
7.2	Micro programmed control	1
7.3	Micro instructions	1
7.4	Micro program sequencing	1
7.5	Micro instructions with next address field and pre-fetching	1
7.6	RAM and ROM	2
7.7	Cache memories and Virtual Memory	2
8	**Input & Output Organization**	
8.1	Accessing I/O devices	1
8.2	Interrupts	1
8.3	Direct Memory Access (DMA)	1
8.4	Interface circuits	1
9	**Advanced Processor Architecture**	
9.1	RISC	1
9.2	Pipelining	1
9.3	Super scalar processors, VLIW, Parallel and vector processors	2
	Total	44

Course Designer(s):

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23DS140	PROBLEM SOLVING USING C PROGRAMMING	Category	L	T	P	Credit
		FC	4	0	0	4

Preamble

The course aims to provide exposure to problem-solving through C programming. It aims to train the students on the basic concepts of the C-programming language with appropriate problems that reflects users' simple computing requirements

Prerequisite

Nil

Course Outcomes

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

CO1	Explain the basic constructs of programming languages	Understand
CO2	Given a computational problem, abstract the programming task involved with algorithm and flowchart	Apply
CO3	Write C programs with suitable operators and control flow statements for given user requirements.	Apply
CO4	Develop C programs with arrays and pointers in the context of functions with an understanding on the basic constructs of a programming language involving character and string functions	Apply
CO5	Apply the concept of structures and unions in developing application-oriented program in C	Apply
CO6	Develop C programs for user requirements with file operations	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	S	-	-	-	-	-	-	-	L	L
CO2	S	M	L	-	S	-	-	-	M	-	-	-	M	M
CO3	S	M	L	-	S	L	L	-	M	-	-	-	M	M
CO4	S	M	L	-	S	L	L	-	M	-	-	-	M	M
CO5	S	M	L	-	S	L	L	-	M	-	-	-	M	M
CO6	S	M	L	-	S	L	L	-	M	-	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	5																							5	5				
CO2	5	5	20						50																5		10			
CO3	5	10	20						25																	5	15			
CO4			20						25				5		20						40				5		15			
CO5													10	10	20						30					10	10			
CO6													5	10	20						30				5		10			
Total (in %)	100						100						100						100						100					

Syllabus

Computing and problem solving: Fundamentals of Computing, Algorithms, Pseudocode and flowcharts. Role of programming languages, Memory, Variables, Values, Instructions, Programs, The Role of Programming Languages, Structured Programming.

Types, operators and expressions: Variables, Data types – constants – Declarations – Storage classes - Arithmetic, relational and logical operators - Type conversions – Increment, Decrement and bitwise operators – Assignment operators and expressions - conditional expressions – Precedence and order of evaluation – Practice problems

Control flow: Statements and blocks – Decision control structures – Looping control structures - Case control structures – Break and continue – Practice problems

Functions and Program Structure: Basics – Function Prototyping - Function Call by value - Function Call by reference – Recursion – Practice problems

Pointers and Arrays: Basic of pointers and arrays - Pointer Arithmetic - Pointers to array - Pointers to function - Multidimensional arrays and pointers –Practice problems

Structures and Unions: Motivation and examples – Structures and functions – Array of structures – Pointer to structures – Self-referential structures – Dynamic allocation - Table lookup – Unions – Bit fields - Practice problems

I/O Management: Input and output from console – Standard input – Formatted output – Variable length argument lists – Formatted input - File Management in C – File access – Error handling - Practice problems

Reference Books

1. Byron S Gottfried,"Programming with C", 4th Edition, 2018
2. Yashavant Kanetkar, "Let Us C: Authentic guide to C programming language" , 18th Edition, BPB Publications, 2021
3. Sumitabha Das, "Computer Fundamentals and C Programming", McGraw Hill Education, 2018
4. Reema Thareja "Computer fundamentals and programming in C", Oxford University, Second edition, 2017
5. Brian W Kernighan & Dennis Ritchie, "The C programming language", 2nd Edition, Prentice Hall , 2015

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to computing and problem solving**	
1.1	Fundamentals of Computing, Algorithms, Pseudo-code and flowcharts	1
1.2	Role of programming languages, Memory, Variables, Values, Instructions, Programs	1
1.3	Structured Programming	1
2	**Types, operators and expressions:**	
2.1	Variables and Data types , constants	1

Module No.	Topic	No. of Periods
2.2	Arithmetic, relational and logical operators	1
2.3	Type conversions	1
2.4	Increment, Decrement and bitwise operators	1
2.5	Assignment operators	1
2.6	conditional expressions	1
2.7	Precedence and order of evaluation	1
2.8	Practice problems	1
3	**Control flow:**	
3.1	Statements and blocks	1
3.2	Decision control structures	1
3.3	Looping control structures	1
3.4	Case control structures	1
3.5	Practice problems	1
4	**Functions and Program Structure:**	
4.1	Basics	1
4.2	Function Prototyping	1
4.3	Function Call by value	1
4.4	Function Call by reference	1
4.5	Recursion	1
4.6	Practice problems	1
5	**Pointers and Arrays:**	
5.1	Basic of pointers and arrays	1
5.2	Pointers to array	1
5.3	Pointers to function	1
5.4	Multidimensional arrays and pointers	1
5.5	Practice problems	1
6	**Structures and Unions:**	
6.1	Motivation and examples	1
6.2	Structures and functions	1
6.3	Array of structures	1
6.4	Self-referential structures	1
6.5	Pointer to structures	1
6.6	Dynamic allocation	1
6.7	Unions	1
6.8	Practice problems	2
7	**I/O Management:**	
7.1	Input and output from console	1

Module No.	Topic	No. of Periods
7.2	Standard input and Formatted output	1
7.3	Variable length argument lists	1
7.4	Formatted input	1
7.5	File Management in C	1
7.6	File access	1
7.7	Error handling	1
7.8	Practice problems	1
	Total	44

Course Designer(s):

Ms. P. Sharmila, psaca@tce.edu
Assistant Professor in Data Science,
Dept. of Applied Mathematics and Computational Science

		Category	L	T	P	Credit
23DS150	**DISCRETE STRUCTURES**	FC	4	0	0	4

Preamble

This course will provide an outline to equivalent logical proposition for a real-world statement by applying predicates and quantifiers and to develop fundamental knowledge of combinatorics. This course also helps to apply the Laws using Lattices and Boolean algebra and prove the properties and construct the Automata to reduce the complexity of a model.

Prerequisite

Nil

Course Outcomes

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

CO1	Prove implication problems using truth table method, truth table technique, rules of inference to obtain PCNF and PDNF of given logical expression.	Apply
CO2	Construct verbal arguments with predicates in symbolic form after validating them using inference	Apply
CO3	Represent the different types of relation in matrix, digraph and vice versa.	Apply
CO4	Prove using mathematical induction and problems using permutations and combinations.	Apply
CO5	Prove the properties of Lattices and Boolean algebra.	Apply
CO6	Construct DFA and NFA with given language considering the grammar	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	L	L	L	M	M	M	-	-	-	-	-	-	L	M
CO2.	S	S	M	M	-	M	-	-	-	-	-	-	L	S
CO3	S	S	M	M	-	-	-	-	-	-	-	-	L	S
CO4	S	S	M	S	M	M	-	-	-	-	-	-	L	S
CO5	S	S	M	S	M	-	-	-	-	-	-	-	L	S
CO6	S	S	L	L	M	M	-	-	-	-	-	-	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10	20						40																	5	16			
CO2	5		20						30																2		8			
CO3		10	30						30																2	5	8			
CO4													5	10	30						40				2	5	12			
CO5													5	10	20						30				2	5	16			
CO6															20						30				2		10			
Total (in %)	100						100						100						100						100					

Syllabus

Mathematical logic:

Propositional Logic: Introduction, Connectives. Tautology and Contradiction. Logical Equivalences and Logical Implications. Normal forms: CNF, DNF, PCNF, PDNF. Theory of Inferences - Rules of Inference – Consistency of premises. Validity by truth table technique.

Predicate Calculus: Predicates - Statement Function, Variables and Quantifiers, Theory of inferences of Predicate Calculus.

Set Theory:

Relations: Relations, Binary relations, Equivalence relations and Partitions, Matrix representation of a relation, relation representation by graphs. Partially ordered set (PO Set), Hasse Diagram, LUB, GLB. **Functions**: Types, Composition of functions, Inverse of a function, Recursive functions.

Combinatorics:

Mathematical Induction. Basics of Counting. Pigeonhole Principle. Permutations and Combinations. Recurrence relations. Principle of Inclusion and Exclusion.

Lattices & Boolean Algebra:

Lattices – Principle of Duality - Properties of lattices, Sub lattices, Special lattices. Properties of Boolean algebra – Dual and Principle of Duality – Sub algebra. Boolean Homomorphism, Expressions and Functions.

Grammar and Automata Theory:

Grammar: Phrase-Structure Grammars - Types of Grammar.

Automata Theory: Overview of Finite - State Machine, Input and Output strings of FSM, Finite State Automata, Pushdown Automaton, Turing Machine. Pumping Lemma.

Reference Books and Web Resources

1. Kenneth H. Rosen, “Discrete mathematics and its applications”, McGraw-Hill International Editions, 2021.
2. Trembly and Manohar, “Discrete mathematical structures with applications to Computer Science”, Tata McGraw-Hill, 2017.
3. John E. Hopcraft, Rajeev Motwani, Jeffery D. Ullman, “Introduction to Automata Theory, Languages and Computation”, Pearson Education, Asia, 3rd edition, 2013.
4. Judith L. Gersting, “Mathematical Structures for Computer Science”, W.H. Freeman and Company, 2014.
5. http://www.discrete-math-hub.com/resources-and-help.html#otherstuff
6. https://en.wikibooks.org/wiki/Discrete_Mathematics
7. https://mathworld.wolfram.com/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	Mathematical logic	
1.1	Propositional Logic Introduction, Connectives	1
1.2	Tautology and Contradiction	1
1.3	Logical Equivalences and Logical Implications	1
1.4	Normal forms: CNF, DNF, PCNF, PDNF	2
1.5	Theory of Inferences - Rules of Inference – Consistency of premises. Validity by truth table technique	2
1.6	Predicate Calculus Predicates - Statement Function	1
1.7	Variables and Quantifiers	1
1.8	Theory of inferences of Predicate Calculus	2
2	Set Theory	
2.1	Relations: Binary relations, Equivalence relations and Partitions	1
2.2	Matrix representation of a relation, relation representation by graphs.	2
2.3	Partially ordered set (PO Set), Hasse Diagram, LUB, GLB.	2
2.4	Functions: Types, Composition of functions,	1
2.5	Inverse of a function, Recursive functions.	2
3	Combinatorics	
3.1	Mathematical Induction	1
3.2	Basics of Counting. Pigeonhole Principle.	2
3.3	Permutations and Combinations	2
3.4	Recurrence relations.	2
3.5	Principle of Inclusion and Exclusion.	2
4	Lattices & Boolean Algebra	
4.1	Lattices – Principle of Duality	1
4.2	Properties of lattices, Sub lattices, Special lattices	2

4.3	Properties of Boolean algebra – Dual and Principle of Duality	2
4.4	Sub algebra	1
4.5	Boolean Homomorphism, Expressions and Functions.	2
5	Grammar and Automata Theory	
5.1	Grammar: Phrase-Structure Grammars - Types of Grammar.	1
5.2	Automata Theory: Overview of Finite-state Machine	1
5.3	Input and Output strings of FSM	2
5.4	Finite State Automata, Pushdown Automaton	2
5.5	Turing Machine. Pumping Lemma.	2
	Total	44

Course Designer(s):

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Assistant Professor in Data Science,
Dept. of Applied Mathematics and Computational Science.

23DS170 C PROGRAMMING LAB	Category	L	T	P	Credit
	FC	0	0	4	2

Preamble

The course aims to provide exposure to problem-solving through C programming and involves a lab component which is designed to give the student hands-on experience with the concepts.

Prerequisite

Nil

Course Outcomes

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

CO1	Implement C programs by choosing suitable datatypes and apply the concept of Control Structures to solve any given problem	Apply
CO2	Apply the concept of single and multi-dimensional arrays to solve problems related to searching, sorting and matrix operations.	Apply
CO3	Develop C programs using the concept of user-defined and recursive functions.	Apply
CO4	Develop C Programs by applying the concept of structures and unions	Apply
CO5	Implement C programs for demonstrating pointer concepts.	Apply
CO6	Implement C programs to create and process data files.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	S	S	S	L	L	L	L	-	L	L	L	L	L	L
CO2.	S	S	S	L	L	L	L	-	L	L	L	L	L	L
CO3	S	S	S	L	L	L	L	-	L	L	L	L	L	L
CO4	S	S	S	L	L	L	L	-	L	L	L	L	L	L
CO5.	S	S	S	L	L	L	L	-	L	L	L	L	L	L
CO6	S	M	M	L	L	L	L	-	L	L	L	L	L	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Simple programs to demonstrate data types and storage classes
2. Familiarizing conditional, control and looping statements.
3. Usage of single and double dimensional arrays
4. Implementation of functions and recursive functions (call by value and reference)
5. Defining and handling structures, array of structures and union.
6. Implementation of pointers- operation on pointers and pointer arithmetic
7. Implementation of dynamic storage allocation.
8. Creating and processing data files.

Reference Books

1. Yashavant Kanetkar, “Let Us C : Authentic guide to C programming language” , 18th Edition, BPB Publications, 2021.
2. Brian W Kernighan & Dennis Ritchie, ”The C programming language”, 2nd Edition, Prentice Hall ,2015 Chapters 1,2,3,4,5,6,7
3. H. M. Deitel, P. J. Deitel, “C: How to program”, 7th edition, Pearson Education, 2010. Chapter 13
4. R. G. Dromey, "How to Solve It By Computer", 12 th Edition, Pearson Education, 2007
5. Darnell and Margolis, ”ANSI C- A Systematic programming Approach” Narosa publications, 2010.

Course Designer:

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Department of Applied Mathematics and Computational Science.

23DS180 PROFESSIONAL ENGLISH

Category	L	T	P	Credit
EEC	0	2	2	3

Preamble

The course will equip the students to apply knowledge and language skills to thrive in the digital era where data and information are recognized as pivotal to the academic, professional, and social life.

Prerequisite

Nil

Course Outcomes

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

CO1	Associate the meaning with its vocabulary	Understand
CO2	Adapt practical techniques to listen and comprehend various speeches with the required emphasis	Apply
CO3	Read for Comprehending various texts	Understand
CO4	Express their ideas clearly and effectively in both spoken and written communication	Apply
CO5	Explore critically and analytically about common social issues	Apply
CO6	Discover a spirit of inquiry	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									S	S			L	L
CO2									S	S			L	L
CO3									S	S			L	L
CO4									S	S			L	L
CO5									S	S			L	L
CO6									S	S			L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Internal

No Common Continuous Assessment Test (CAT) will be conducted.

Students' performance will be continuously assessed in various classroom activities on Listening,Speaking, Reading and Writing for 60 marks as detailed below

Listening Test	-	10
Speaking Test- Presentation /Brainstorming	-	25
Written Test (Basic Grammar and Paragraph Writing)	-	25

External (Practical)

Listening	- 20
Speaking (Presentation)	- 20
Brain storming on Social Issues	- 10
Writing	- 50

(Vocabulary Building, Synonyms and Antonyms, One-word Substitutions, Idioms & Phrases, SV Agreement, Tenses, Voices, Prepositions, Adjectives and Adverbs)

Syllabus

Module 1: Basic Grammar – Subject Verb Agreement, Tenses / Voices, Preposition, Adjectives and Adverbs

Module 2 : Vocabulary Building- Synonyms and Antonyms, One Word Substitution, Idioms & Phrases

Module 3 : Listening Skill – Listening to various TED talks and Documentaries

Module 4 : Speaking Skill – SWOT Analysis, Elevator Pitch, Brainstorming on various social issues, Presentation Strategy, Presentation using various digital tools, Facing and handling difficult questions

Module 5 : Reading Skill – Skipping, skimming, scanning , Intensive reading, Reading comprehension
Extensive Reading – 'The Power of Positive Thinking' by Norman Vincent Peale

Module 6 : Writing Skill - Coherent markers, Logical Sequence of Sentences and Paragraphs, Interpretation of Graphics, Writing Agenda & Minutes

Reference Books and web resources

1. Courseware on "Technical Communication for Scientists and Engineers", IIT Bombay,2015.
2. Lewis, Norman. "How to Read better & Faster". New Delhi: Binny Publishing House. 1978
3. McCarthy, Michael and Felicity O'Dell. "English vocabulary in use : 100 Units of Vocabulary reference and practice" in Cambridge: CUP. 1996
4. N.M. White, " Unlock – Listening and Speaking Skills 1" Cambridge University Press, 2014
5. https://www.ted.com/talks
6. "Elephant Whisperers" – Documentary, 2022
7. Online YouTube videos on Current Issues

Extensive Reading – Norman Vincent Peale, "The Power of Positive Thinking", Readers' Paradise, 2020

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods	
		Tutorials	Lab
1	**Basic Grammar**		1
1.1	Tenses / Voices	1	
1.2	Subject Verb Agreement	1	
1.3	Preposition	1	
1.4	Adjectives and Adverbs	1	

2	**Vocabulary Building**		2
2.1	Synonyms and Antonyms	1	
2.2	One word substitution	1	
2.3	Idioms and Phrases	2	
3	**Listening Skills**		
3.1	Listening to TED Talks and Documentaries		4
4	**Speaking Skills**		
4.1	SWOT Analysis	1	1
4.2	Elevator Pitch (Video Recording)	1	2
4.3	Brainstorming on various social issues	2	2
4.4	Presentation Strategy, Facing and handling difficult questions	2	2
4.5	Preparing presentation using various digital tools		4
5	**Reading Skills**		
5.1	Skimming, skipping and scanning , and Intensive Reading Skills	2	
5.2	Reading Comprehension	1	2
6	**Writing Skills**		
6.1	Coherent Markers, Logical Sequence of Sentences and Paragraphs	2	
6.2	Paragraph Writing	1	
6.3	Interpretation of Graphics	2	
6.4	Writing Agenda and Minutes	2	
	Practice Test on LSRW Skills		4
		24	24
	Total	**48 hours**	

Course Designer(s):

1. Dr.A.Tamilselvi, Professor, Department of English — tamilselvi@tce.edu
2. Dr.RS.Swarnalakshmi, Assistant Professor, Department of English — rssleng@tce.edu

		Category	L	T	P	Credit
23DS210	**THEORY OF PROBABILITY**	FC	4	0	0	4

Preamble

This course will enable students to apply conditional probability, Bayes' theorem to solve real time problems and to learn the concepts of moment generating functions to discrete and continuous distributions and find the probability values for the defined distributions. Also, the course enables them to learn the concepts of Limit theorems and realize the applications of central limit theorem

Prerequisite

Nil

Course Outcomes

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

CO1	Apply the concepts of basics of probability, conditional Probability and Bayes' Theorem to solve the real world problems	Apply
CO2	Infer discrete and continuous random variables, probability mass function and density function, expectation and variance	Apply
CO3	Apply the concepts of discrete and continuous distributions as binomial, Bernoulli, Poisson, geometric, uniform, normal, exponential, Weibull, and gamma distributions to the real world problems	Apply
CO4	Apply joint probability distributions to find marginal and conditional distributions and also transformation of two random variables	Apply
CO5	Apply the concepts of random variables and distributions for the central limit theorem.	Apply
CO6	Apply the concept of reliability for system of independent Components and expected system lifetime.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	L	L	L	M	L	-	-	-	-	-	-	-	L	M
CO2.	S	S	M	M	L	-	-	-	-	-	-	-	L	S
CO3	S	S	M	M	L	-	-	-	-	-	-	-	L	S
CO4	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO5	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO6	S	S	L	L	-	-	-	-	-	-	-	-	L	S

s- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	10	20						30																2	5	8			
CO2	4	10	20						35																2	5	10			
CO3	2	10	20						35																	5	16			
CO4													4	10	30						35				2	5	16			
CO5													2	10	20						35				2		12			
CO6													4		20						30				2		8			
Total (in %)	100						100						100						100						100					

Syllabus

Probability Basic Concepts:
Introduction - Sample space and events – Basic Theorems - Conditional Probability – Baye's Theorem - Independence.

Random Variables:
Discrete and continuous random variables - probability mass function and density function - Distribution function - Expectation and variance – Moments and Moment Generating functions - Sums of independent random variables.

Theoretical Distributions:
Discrete: Binomial, Bernoulli, Poisson and Geometric.
Continuous: Uniform, Normal, Exponential, Weibull, and Gamma.

Two-Dimensional Random Variable:
Joint probability distributions - Marginal and conditional distributions - Statistical independence - Conditional expectation — Transformation of two random variables.

Central Limit Theorems:
Limit theorems: Markov and Chebyshev inequalities, Law of Large numbers, Central Limit Theorem.

Reliability:
Introduction - Structure Functions - Reliability of Systems of Independent Components - System Life as a Function of Component Lives - Expected System Lifetime.

Reference Books and Web Resources

1. Sheldon M. Ross, "Introduction to Probability Models", Academic Press, 12th edition 2019.
2. Saeed Ghahramani, "Fundamentals of Probability with Stochastic Processes", Pearson Education, 4th edition 2019.
3. Jay L Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, 2015.
4. K. S. Trivedi, "Probability and Statistics with Queuing, Reliability and Computer Science Applications", John Wiley &Sons, 2016.
5. https://www.khanacademy.org/math/statistics-probability
6. https://www.probabilitycourse.com/
7. https://mathworld.wolfram.com/topics/ProbabilityandStatistics.html

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	Probability Basic Concepts:	
1.1	Introduction and Sample space and events	1
1.2	Axiomatic approach to probability – Basic theorems.	1
1.3	Conditional Probability	1
1.4	Law of multiplication	1
1.5	Law of total probability and Bayes Theorem	1
1.6	Independence	2
2	Random Variables:	

Module No.	Topic	No. of Periods
2.1	Discrete random variables	1
2.2	Continuous random variables	1
2.3	probability mass function and density function	2
2.4	distribution function	1
2.5	Expectation and variance	2
3	Theoretical Distributions:	
3.1	Discrete: Binomial, Bernoulli	2
3.2	Poisson, Geometric.	2
3.3	Continuous: Uniform, Normal	2
3.4	Exponential, Weibull, and Gamma.	2
4	Two Dimensional Random Variables:	
4.1	Joint probability distributions	1
4.2	Marginal and conditional distributions	2
4.3	Statistical independence	1
4.4	Conditional expectation	1
4.5	Transformation of two random variables.	2
5	Central Limit Theorems:	
5.1	Moments and moment generating functions	2
5.2	Sums of independent random variables	1
5.3	Limit theorems: Markov and Chebyshev inequalities	2
5.4	Law of Large numbers	1
5.5	Central Limit Theorem.	1
6	Reliability:	
6.1	Introduction - Structure Functions	2
6.2	Reliability of Systems of Independent Components	2
6.3	System Life as a Function of Component Lives	2
6.4	Expected System Lifetime	2
	Total	44

Course Designer(s):

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Dept. of Applied Mathematics and Computational Science.

		Category	L	T	P	Credit
23DS220	**APPLIED STATISTICS**	PCC	4	0	0	4

Preamble

The students will be able to learn the data analysis with the basics of graphs and tables, Test the hypothesis on mean, variance, proportion of small and large samples, for goodness of fit and independence of attributes and apply the concept of correlation, linear and nonlinear regressions to Data Science problems.

Prerequisite

Nil

Course Outcomes

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

CO1	Learn the basic concepts of distributions, charts and various types of measures.	Understand
CO2	Apply the concepts of estimation and its type in mean, proportion and variance.	Apply
CO3	Demonstrate the concept of testing of hypothesis for small and large samples by using various tests like t-test, F-test, z-test and chi-square test	Apply
CO4	Apply the concept of Correlation and regressions to engineering problems Apply least square method in fitting linear and nonlinear regression curves.	Apply
CO5	Apply Multiple regression and correlation analysis, Inferences about population parameters and Modeling techniques.	Apply
CO6	Apply the concepts of Analysis of variance in real life problems	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	-	-	-	-	-	-	-	-	S	S
CO2	S	M	M	M	-	-	-	S	-	-	-	-	S	S
CO3	S	M	M	M	-	-	-	-	S	-	-	-	S	S
CO4	S	M	M	M	-	-	-	-	-	-	-	M	S	S
CO5	S	M	M	M	-	-	-	-	-	-	-	-	S	S
CO6	S	M	L	M	-	-	-	-	-	-	-	-	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10																							2	5				
CO2	5	10	30						50																2	5	10			
CO3		10	30						50																2		20			
CO4													5	10	20						50				2	5	10			
CO5													5	10	20						25				2	5	10			
CO6														10	20						25					10	10			
Total (in %)	100						100						100						100						100					

Syllabus

DESCRIPTIVE STATISTICS: Frequency distribution – Bar graphs and Pie charts – Histogram- Ogive — Simpson's paradox — Measures of Location — Measures of Variability – Measures of distribution shape, relative location and detecting outliers – Exploratory Data analysis, Stem-and-leaf display – Measures of Association between two variables.

STATISTICAL INFERENCE: Sampling distribution - Estimation: Point estimation, interval estimation - Criteria of a good estimator — Interval estimation of mean, proportion, and variance (single sample and two samples).

HYPOTHESIS TESTING: General concepts - Errors in Hypothesis testing - One-and two-tailed tests - Tests concerning mean, proportion, and variance - Tests for Goodness of fit and independence of attributes.

CORRELATION AND REGRESSION: introduction - Estimation using the regression line - Correlation analysis -Limitations, errors, and caveats of using regression and correlation Analyzes - Multiple regression and correlation analysis - Inferences about population parameters — Modeling techniques.

ANALYSIS OF VARIANCE: Introduction to design of experiments, Analysis of variance.

TOOLS: d3.js, Excel, Tableau.

Reference Books

1. Richard I. Levin. David S. Rubin, "Statistics for Management", Pearson Education, 2017.
2. Ronald E. Walpole, Raymond H. Meyers and Sharon L. Meyers, "Probability andStatistics for Engineers and Scientists", Pearson Education, 2019.
3. L. Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, 2018.
4. Anderson, Sweeney and Williams , "Statistics for business and economics", CengageLearning, 2014.
5. Saeed Ghahramani, "Fundamentals of Probability with Stochastic Processes", Pearson Education, 2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**DESCRIPTIVE STATISTICS:**	
1.1	Frequency distribution	2
1.2	Bar graphs and Pie charts	1
1.3	Histogram- Ogive – Simpson's paradox	2
1.4	Measures of Location – Measures of Variability	2
1.5	Measures of distribution shape, relative location and detecting outliers	2
1.6	Exploratory Data analysis, Stem-and-leaf display	2

1.7	Measures of Association between two variables	2
2	**STATISTICAL INFERENCE**:	
2.1	Sampling distribution - Estimation:	2
2.2	Point estimation, interval estimation	2
2.3	Criteria of a good estimator – Interval estimation of mean, proportion, and variance (single sample and two samples)	2
2.4	Maximum likelihood estimator	2
2.5	Hypothesis Testing: General concepts - Errors in Hypothesis testing	2
2.6	One-and two-tailed tests	2
2.7	Tests for Goodness of fit and independence of attributes	1
3	**CORRELATION AND REGRESSION:**	
3.1	Introduction - Estimation using the regression line	2
3.2	Correlation analysis -Limitations	2
3.3	Errors, and caveats of using regression and correlation	2
3.4	Multiple regression and correlation analysis	2
3.5	Inferences about population parameters	2
3.6	Modelling techniques	2
4	**ANALYSIS OF VARIANCE:**	1
4.1	Introduction to design of experiments,	2
4.2	Analysis of variance	1
4.3	Completely Randomized Design and Randomized Block Design.	1
5.0	Tools: d3.js, Excel, Tableau.	2
	Total	**45**

Course Designers:

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		Category	L	T	P	Credits
23DS230	**GRAPH THEORY**	FC	4	0	0	4

Preamble

This course will enable students to learn some basic types of graphs, connectivity and the complexity of the model and create the model to real time problem through graphs. It also enables to learn the random graphs and Ramsey numbers to apply in the social networks.

Prerequisite

- Nil

Course Outcomes

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

CO1	Explain the basic concepts of Graphs, walk, path, circuits and apply the concepts of Eulerian, Hamiltonian graphs in real life problems.	Apply
CO2	Explain the concepts of digraphs and relate the application of graph theory to computer science field.	Apply
CO3	Apply the concepts of trees and connectivity for network problems.	Apply
CO4	Apply the concepts of planarity and duality for solving geometric problems.	Apply
CO5	Use the matrix representation and solve minimum path finding problem.	Apply
CO6	Apply the concepts of Colouring, Covering and Domination for solving real time problems.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	S	-	-	L	-	-	-	-	-	L	M
CO2	S	S	S	S	-	-	-	-	-	-	-	-	L	S
CO3	M	M	S	S	-	-	-	-	-	-	-	-	L	S
CO4	S	S	S	S	-	-	M	-	-	-	-	-	L	S
CO5	S	S	S	S	-	-	M	-	-	-	-	-	L	S
CO6	M	S	S	S	-	-	M	-	-	-	-	-	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	4	10	20						30																4	5	10			
CO2	2	10	20						40																2	-	20			
CO3	4	10	20						30																2	5	10			
CO4													4	10	20						30				2	-	10			
CO5													2	10	20						40				-	5	10			
CO6													4	10	20						30				-	5	10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION: Graphs and its Applications, Finite and Infinite Graphs, Incidence and Degree, Isolated Vertex, Pendent Vertex and Null Graph. Isomorphism, Sub graphs, Walks, Paths and Circuits, Connected and Disconnected Graphs and Components, Euler Graphs, Hamiltonian Paths and Circuits, Travelling Salesman Problem.

DIRECTED GRAPHS: Digraphs and Binary Relations Directed Paths and Connectedness, Euler Digraphs, Trees with Directed Edges, Acyclic Digraphs and Decyclization.

TREES AND FUNDAMENTAL CIRCUITS: Trees and its Properties, Distance and Canters, Rooted and Binary Trees, Spanning Trees. **Cut-Sets and Cut-Vertices:** Properties, Connectivity and Separability, Network Flows, 1-Isomorphism, 2-Isomorphism.

PLANAR AND DUAL GRAPHS: Planar Graphs, Kuratowski's Two Graphs, Combinatorial and Geometric Graphs and its Dual.

MATRIX REPRESENTATION OF GRAPHS: Incidence Matrix, Matrix - Path, Adjacency, Cut-Set, Application to a Switching Network.

COLORING, COVERING AND PARTITIONING: Chromatic Number, Partitioning, Polynomial, Matching, Coverings, Four Colour Problem.

Reference Books and Web Resources:

1. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", 2016.
2. Douglas B. West, "Graph Theory", Pearson Education, 2015.
3. Bondy J.A. and Murty U.S.R, "Graph Theory", Springer, 2013.
4. Balakrishnan R and Ranganathan K, "A Textbook of Graph Theory", Springer-Verlag, 2012.
5. https://www.graphclasses.org/index.html
6. https://t5k.org/graph/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Basic Definitions of graphs with examples	3
1.2	Paths and Circuits concepts with example	3
1.3	Classify the Eulerian and Hamiltonian graphs	3
2	**DIRECTED GRAPHS**	
2.1	Digraphs and Binary Relations	2
2.2	Directed Paths and Connectedness	2
2.3	Trees with Directed Edges, Acyclic Digraphs and Decyclization.	3
3	**TREES & CONNECTIVITY**	

Module No.	Topic	No. of Periods
3.1	Trees and its Properties	2
3.2	Concepts of Rooted, Binary Trees and Spanning Trees	2
3.3	Concepts of Connectivity and Separability	2
3.4	Explanation of Network Flows, 1-Isomorphism, 2-Isomorphism	2
4	**PLANARITY & DUALITY**	
4.1	Concepts of Planar Graphs and its applications.	2
4.2	Kuratowski's algorithm of two Graphs	2
4.3	Classify the Geometric Graphs and it's Dual	2
5	**MATRIX REPRESENTATION**	
5.1	Incidence Matrix, Matrix - Path	2
5.2	Adjacency & Cut-set	2
5.3	Application to a Switching Network	2
6	**COLORING, COVERING AND PARTITIONING**	
6.1	Concepts of Coloring.	2
6.2	Chromatic Number, Four colour theorem.	2
6.3	Matchings & Coverings and its applications.	2
6.4	Partitioning & Polynomial of graphs.	2
	Total	44

Course Designer(s):

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23DS240 OBJECT ORIENTED PROGRAMMING

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

To provide sound knowledge on basic and advanced concepts of Object-Oriented programming and apply them in developing industrial strength software applications.

Prerequisite

- 23DS140 Problem Solving Using C programming.

Course Outcomes

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

CO1	Explain the differences between structural and object oriented programming	Understand
CO2	Identify classes, relevant data representations, operations and interactions for the entities in a given problem description.	Apply
CO3	Develop object-oriented programs by applying Abstraction, Encapsulation and Information hiding.	Apply
CO4	Practice code reusability and extensibility by means of Inheritance and Polymorphism.	Apply
CO5	Illustrate the use of templates and template libraries for a given user requirement	Apply
CO6	Write C++ programs with I/O streams and file objects for a given user requirement	Apply
CO7	Select suitable object-oriented programming constructs for developing real time applications.	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	S	M	S	-	L	-	-	-	-	-	-	-	M	L
CO2.	S	S	S	L	L	-	-	-	-	-	-	-	S	M
CO3	S	S	S	M	M	L	-	-	L	-	-	-	S	M
CO4	S	S	S	M	M	L	-	L	M	-	L	-	S	M
CO5	S	S	S	M	M	-	-	-	-	-	-	-	S	M
CO6	S	S	S	M	M	-	-	L	-	-	-	-	S	M
CO7	S	S	S	M	M	L	-	L	M	-	M	L	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10																							4	5				
CO2	5	10	20																						4		10			
CO3		10	20						50																4	5	10			
CO4			20						50																4	5	10			
CO5													5	10	20						25				2		10			
CO6													5	10	20						25				2	5	10			
CO7														10		20						50						10		
Total (in %)	100						100						100						100						100					

Syllabus

Principles of Object Oriented Programming: Software crisis Software Evolution - Procedure Oriented Programming - Object Oriented Programming Paradigm - Basic Concepts and Benefits of OOP - Object Oriented Programming Language - Application of OOP.

Structure of C++: Tokens, Expressions and Control Structures - Operators in C++ - Manipulators.

Functions in C++: Function Prototyping - Call by Reference - Return by reference - Inline functions - Default, Const Arguments - Function Overloading

Classes and Objects: Member functions - Nesting of Member functions - Private member functions - Memory allocation for Objects - Static data members - Static Member Functions - Arrays of Objects - Objects as Function Arguments - Friend Functions - Returning Objects - Const Member functions - Pointers to Members – Virtual functions.

Constructors: Parameterized Constructors - Multiple Constructors in a Class - Constructors with Default Arguments - Dynamic Initialization of Objects - Copy and Dynamic Constructors – Destructor overloading.

Operator Overloading: Overloading Unary and Binary Operators - Overloading Binary Operators using Friend functions – Operator Type conversion.

Inheritance: Defining Derived Classes - Single Inheritance - Making a Private Member Inheritable - Multiple Inheritance - Hierarchical Inheritance - Hybrid Inheritance - Virtual Base Classes - Abstract Classes - Constructors in Derived Classes - Member Classes - Nesting of Classes – Composition – Aggregation.

Polymorphism: Basics of polymorphism – Types of polymorphism - Compile and Run Time Polymorphism - Virtual function – Object Slicing – Virtual Destructor – Dynamic binding.

Templates & Exception Handling: Introduction to Templates, Generic Functions and Generic Classes – Exception Handling – STL Components.

Streams: String I/O - Character I/O - Object I/O - I/O with multiple Objects - File pointers - Disk I/O with member functions.

Reference Books

1. Bjarne Stroustrup, “The C++ Programming Language”, Pearson Education, 2013.
2. Yashavant P. Kanetkar, “Let Us C++”, BPB Publications, 2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Principles of Object Oriented Programming**	
1.1	Software crisis Software Evolution - Procedure Oriented Programming - Object Oriented Programming Paradigm	2
1.2	Basic Concepts and Benefits of OOP -Object Oriented Programming Language	2
1.3	Application of OOP	1
2	**Structure of C++**	

Module No.	Topic	No. of Periods
2.1	Tokens, Expressions and Control Structures	1
2.2	Operators in C++ - Manipulators	1
3	**Functions in C++**	
3.1	Function Prototyping - Call by Reference - Return by reference	1
3.2	Inline functions - Default, Const Arguments	1
3.3	Function Overloading.	1
4	**Classes and Objects**	
4.1	Member functions - Nesting of Member functions - Private member functions	2
4.2	Memory allocation for Objects - Static data members - Static Member Functions	2
4.3	Arrays of Objects - Objects as Function Arguments - Friend Functions	1
4.4	Returning Objects - Const Member functions - Pointers to Members- virtual functions.	1
5	**Constructors**	
5.1	Parameterized Constructors - Multiple Constructors in a Class	1
5.2	Constructors with Default Arguments - Dynamic Initialization of Objects	2
5.3	Copy and Dynamic Constructors – Destructors overloading.	2
6	**Operator Overloading**	
6.1	Overloading Unary and Binary Operators	1
6.2	Overloading Binary Operators using Friend functions	2
6.3	Operator Type conversion	1
7	**Inheritance**	
7.1	Defining Derived Classes - Single Inheritance - Making a Private Member Inheritable	2
7.2	Multiple Inheritance - Hierarchical Inheritance - Hybrid Inheritance	1
7.3	Virtual Base Classes - Abstract Classes - Constructors in Derived Classes	1
7.4	Member Classes - Nesting of Classes – Composition – Aggregation	2
8	**Polymorphism**	
8.1	Basics of polymorphism – Types of polymorphism	2

Module No.	Topic	No. of Periods
8.2	Compile and Run Time Polymorphism - Virtual function	1
8.3	Object Slicing – Virtual Destructor – Dynamic binding	2
9	**Templates & Exception Handling**	
9.1	Introduction to Templates, Generic Functions and Generic Classes	2
9.2	Exception Handling – STL components.	2
10	**Streams**	
10.1	String I/O -Character I/O - Object I/O	1
10.2	I/O with multiple Objects - File pointers	2
10.3	Disk I/O with member functions.	1
	Total	**44**

Course Designer(s)

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23DS250	ORGANIZATIONAL THEORY AND BEHAVIOUR	Category	L	T	P	Credit
		PCC	3	0	0	3

Preamble

To learn challenges and opportunities in organizations from a behavioral science perspective.

Prerequisite

Nil

Course Outcomes

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

CO1	Develop an Organisational Behaviour model for any type of Organization.	Apply
CO2	Develop Managerial skills for Individual Behaviours.	Apply
CO3	Develop the quality of Leadership.	Apply
CO4	Analyze the Common biases and eradication in Decision Making Process.	Analyze
CO5	Adapt to the organizational culture.	Apply
CO6	Analyze how to manage the Stress during a job.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	-	-	-	-	-	-	-	-	-	L	-
CO2	S	M	-	-	-	-	-	-	S	-	-	-	L	-
CO3			-	-	-	-	-	-	-	-	M	-	L	-
CO4	S		M	-	-	-	-	M	-	-	S	-	-	L
CO5	S	S	M	-	-	-	-	-	-	-	-	-	-	L
CO6	S	S	L	-	-	-	-	-	-	-	-	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10	20						50																2	5				
CO2	5	10	20						25																2	5	10			
CO3		10	20						25																2	5	10			
CO4														10	10	20						30			2	5		20		
CO5													5	10	15						40				2	5	10			
CO6													5	10		15						30				5		10		
Total (in %)	100						100						100						100						100					

Syllabus

Organizational Behavior: Introduction to Organizational Behavior(OB), Contributing disciplines to OB Field, challenges and opportunities for OB, Developing an OB Model, Foundation of Individual Behavior, Ability - Learning. Values, Attitudes and Types of Attitudes.

Job satisfaction- Measuring Job satisfaction, Effect of Job satisfaction on employee performance.

Personality and Values: Personality determinants, Achieving personality fit, Factors Influencing perception, Attribution Theory, Perception / Individual Decision Making: Ethics in Decision Making. Motivation, Management by Objectives.

Understanding work teams: Teams Vs Groups – Types of Teams, Creating Effective Teams – Turning Individuals into Team Players.

Communication: Functions of Communication, Communication Process – Direction of communication, Interpersonal and Organizational communication, Barriers of effective communication, Current issues in Communication.

Leadership: Leadership – Meaning, Trait Theories – Behavioral Theories, Contingency Theories, Contemporary issues in Leadership.

Organizational culture and Stress Management: Meaning – Creating and sustaining culture, How employees learn culture, creating an ethical organizational culture, creating a customer responsive culture, spirituality and organizational culture, Work stress and its Management.

Reference Books

1. Stephen P. Robbins, “Organisational Behaviour”, 11/e, Pearson, 17th Edition 2022 (Chapters 1,3,5, 6, 10,11,12, 16,17)
2. Uma Sekaran, “Organisational Behaviour”, 2/e, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2010.
3. Sharma, R.A, “Organisational Theory and Behaviour”, 2/e, Tata McGraw-Hill Ltd., New Delhi, 2012.

Course Contents and Lecture Schedule

Module .No	Topics	No. of Lectures
1	**Organizational Behavior**	
1.1	Introduction to Organizational Behavior (OB)	1
1.2	Contributing disciplines to OB Field	1
1.3	Challenges and opportunities for OB	1
1.4	Developing an OB Model	1
1.5	Foundation of Individual Behavior	1
1.6	Ability - Learning. Values, Attitudes and Types of Attitudes	1
	Job satisfaction	
1.7	Measuring Job satisfaction.	1

1.8	Effect of Job satisfaction on employee performance.	1
2	**Personality and Values**	
2.1	Personality – Personality determinants	1
2.2	Achieving personality fit	1
2.3	Factors Influencing perception	1
2.4	Attribution Theory	1
	Perception / Individual Decision Making	
2.5	Ethics in Decision Making. Motivation	1
2.6	Management by Objectives	1
3	**Understanding work teams**	
3.1	Teams Vs Groups – Types of Teams	1
3.2	Creating Effective Teams – Turning Individuals into Team Players	1
	Communication	
3.3	Functions of Communication	1
3.4	Communication Process – Direction of communication	1
3.5	Interpersonal and Organizational communication	1
4	**Leadership**	1
4.1	Leadership – Meaning	2
4.2	Trait Theories – Behavioral Theories	1
4.3	Contingency Theories	2
4.4	Contemporary issues in Leadership	2
5	**Organizational culture**	1
5.1	Organizational culture: Meaning – Creating and sustaining culture	1
5.2	How employees learn culture	1
5.3	creating an ethical organizational culture	1
5.4	creating a customer responsive culture	1
5.6	Approaches to Managing organizational change	1
5.7	Creating a Culture	1
5.8	Change in Business	1
5.9	Work stress and its Management	1
	Total	**36**

Course Designers:

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23DS270	PYTHON PROGRAMMING AND APPLIED STATISTICS LAB	Category	L	T	P	Credit
		PCC	0	0	6	3

Preamble

The purpose of this course is to introduce students to the field of programming using Python for statistically displaying and describing data, including the normal curve, regression, probability, statistical inference, confidence intervals, and hypothesis tests, with applications in the real world.

Prerequisite

Nil

Course Outcomes

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

CO1	Make use of branching, looping, strings, and function concepts to develop Python programmes for the given problem.	Apply
CO2	Implement object-oriented programming concepts and file handling in Python.	Apply
CO3	Design a basic data structure using Python programming constructs and its packages.	Apply
CO4	Interpret the usage of packages and libraries in Python programming for exploratory data analysis and data cleaning.	Apply
CO5	Perform the regression-correlation and statistical inference analyses.	Apply
CO6	Perform hypothesis testing (z test, t test, F test, and chi squared test).	Apply

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	S	M	S	L	L	-	-	-	-	-	-	-	S	M
CO2.	S	S	S	L	L	-	-	-	-	-	L	-	S	M
CO3	S	S	S	L	L	-	-	-	L	-	L	-	S	M
CO4	S	S	S	M	M	L	-	L	M	-	L	L	S	S
CO5	S	S	S	M	M	L	-	L	M	-	-	-	S	S
CO6	S	S	S	M	M	L	-	L	M	-	M	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

Develop Python Programs for

1. Basic looping and branching programs.
2. Programs on Dictionary, tuples and Nested Lists.
3. User defined functions.
4. String programs.
5. Classes and Objects.
6. File handling with exceptions.
7. Basic Data structures design using python.

Solve the Statistical Problems using Python:

1. Exploratory Data Analysis and Data Cleaning- Pre-defined libraries & packages.
2. Perform calculations that measure the central tendency – Mean, Median, Mode and dispersion of data – Percentile, Range, Standard Deviation.
3. Visualizing Dispersion & Frequency (Boxplot, Histogram, Bar chart, Pie chart, Line charts, etc.)
4. Implementation of measures of Skewness, moments and kurtosis.
5. Determination of point and interval estimates.
6. Calculate and interpret the correlation coefficient of the two variables. (pearson, Spearman)
7. Perform paired t test, F test and Chi square test.
8. Hypothesis testing & ANOVA.
9. Solve linear regression line using python for the problem.

Reference Books

1. John V.Guttag, “Introduction to Computation and Programming Using Python : With Application to Understanding Data”, Prentice-Hall International publishers, Second Edition, 2017.
2. Yashavant Kanetkar, Aditya Kanetkar, “Let us Python, BPB publication, 1st Edition, 2019.
3. I. Levin Richard, H. Siddiqui Masood, S. Rubin David, Rastogi Sanjay, “Statistics for Management”, Pearson Education, 2017.
4. Ronald E. Walpole, Raymond H. Meyers and Sharon L. Meyers, “Probability and Statistics for Engineers and Scientists”, Pearson Education, 2014.

Course Designer(s)

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23DS280	OBJECT ORIENTED PROGRAMMING LAB	Category	L	T	P	Credit
		PCC	0	0	4	2

Preamble

This course is intended for the students to learn Object Oriented Programming and the design of computer solutions with the programming principles. The course emphasizes on practicing OOP concepts, Functions, Polymorphism, Inheritance and I/O and enables them to apply Object Oriented Programming approach to programming.

Prerequisite

- 23DS170: C Programming LAB

Course Outcomes

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

CO1	Illustrate the basic concepts of objected oriented programming for building object based applications	Apply
CO2	Develop programs using object-oriented concepts like abstraction, encapsulation, polymorphism and inheritance to solve the given problem.	Apply
CO3	Demonstrate overloading of methods and operators with appropriate object-oriented programming constructs for different user specifications with suitable programs	Apply
CO4	Implement templates with standard template libraries and create user defined templates.	Apply
CO5	Develop programs for creating packages and handle exceptions for any real-time requirements	Apply
CO6	Create object-oriented programs to demonstrate file handling	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1:	S	M	L	-	L	L	-	-	-	-	-	-	M	M
CO2:	S	M	L	-	L	L	-	-	-	-	-	-	M	M
CO3:	S	M	L	-	L	L	-	-	-	-	-	-	M	M
CO4:	S	M	L	-	L	L	-	-	-	-	-	-	M	M
CO5:	S	M	L	-	L	M	-	-	-	-	-	-	M	M
CO6:	S	M	L	-	L	M	-	-	-	-	-	-	M	M

S- Strong; M-Medium; L-Low

List of Experiments

Develop programs in C++ for different user specification using the below constructs in the context of classes and objects:

1. Implementation of classes and objects
2. Static member data and methods
3. Objects as Function Arguments and return types
4. Constructor types and its overloading
5. Method Overloading and method overriding with base class and derived class
6. Operator Overloading: Unary and Binary using member function & non-member Function.
7. Aggregation, composition and inheritance
8. Friend Function and Friend Class
9. Use of pointers within classes (this pointer, call and return of objects)
10. Abstract class, Virtual function and creating packages
11. Exception handling
12. File handling
13. Templates and STL Components

Mini project

Reference Books

1. H.M. Deitel and P.J. Deitel, C “How to program Introducing C++ and Java”, Fourth Edition, Pearson Prentice Hall, (2012), Reprint 2020.
2. Yashavant P. Kanetkar, “Let Us C++”, BPB Publications, 2020.

Course Designer(s):

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23DS310	PARTIAL DIFFERENTIAL EQUATIONS AND TRANSFORMS	Category	L	T	P	Credit
		FC	4	0	0	4

Preamble

This course will enable students to mathematically formulate practical problems in terms of partial differential equations, solve them and physically interpret the results using transformations.

Prerequisite

Nil

Course Outcomes

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

CO1	Apply the concept of PDE for certain practical problems to solve them and physically interpret the results.	Apply
CO2	Apply Z transform technique to find the inverse Z transforms to solve the given ordinary differential equation and modelling.	Apply
CO3	Apply Laplace transform technique to find the inverse Laplace, solve the given ordinary differential equation and integral equations.	Apply
CO4	Express the periodic functions arising in the study of engineering problems as Fourier series of Sines and Cosines.	Apply
CO5	Obtain the Fourier series expansion in engineering problems using half range sine and cosine series.	Apply
CO6	Solve some of the well-known integral transforms (like Fourier, Fourier Sine and Cosine) and properties. Also Apply the Fourier concepts in solving Discrete and Fast Fourier transforms.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	S	S	S	M	L	L	-	-	-	-	M	L	S
CO2	M	S	M	S	L	L	L	-	-	-	-	L	L	S
CO3	S	S	M	S	M	L	L	-	-	-	-	M	L	S
CO4	M	S	M	S	L	L	L	-	-	-	-	M	L	S
CO5	S	S	M	S	L	L	L	-	-	-	-	M	L	S
CO6	S	S	M	S	L	L	L	-	-	-	-	M	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	10	20						30																2	5	10			
CO2	2	10	20						40																2	5	10			
CO3	4	-	30						30																2	-	20			
CO4													4	10	20						30				-	5	10			
CO5													2	10	20						30				2	5	10			
CO6													4	-	30						40				2	-	10			
Total (in %)	100						100						100						100						100					

Syllabus

PARTIAL DIFFERENTIAL EQUATIONS: Formation of partial differential equations by elimination of arbitrary constants and functions – Solution of standard types of first order PDE – Lagrange's linear equation – Linear PDE of second and higher order with constant coefficients.

Z-TRANSFORM: Z - transform of standard functions - Properties - Inverse Z-transform — Convolution Theorem – Introduction to Difference operators - Formation and Solution of difference equations.

LAPLACE TRANSFORM: Transforms of Standard Functions - Transforms of derivatives and integrals - Transform of Unit step function and Dirac's delta function – Transforms of Periodic functions - Inverse Laplace transform - Partial Fraction - Convolution Theorem - Method of solving ordinary linear differential equations with constant coefficient and solving integral equations.

FOURIER SERIES: Dirichlet's conditions, statement of Fourier theorem, Fourier coefficients, Even and odd functions, change of scale, Half-range sine and cosine series, RMS value, Parseval's theorem.

FOURIER TRANSFORM: Fourier integrals - Fourier transform - Fourier sine and cosine transform - Transforms of standard functions - Properties, Convolution theorem – Discrete Fourier and Fast Fourier Transforms – Computation of inverse DFT - Properties of DFT.

Reference Books and web resources

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 10th edition 2014.
2. Ray Wylie C, Louis C Barret," Advanced Engineering Mathematics", McGraw Hill, 2013.
3. Roland E. Thomas and Albert J. Rosa, "The Design and Analysis of Linear Circuits", John Wiley & Sons, 2016.
4. Michael D. Greenberg, "Advanced Engineering Mathematics", Pearson Education, 2014.
5. https://www.khanacademy.org/math/differential-equations/laplace-transform
6. https://tutorial.math.lamar.edu/Classes/DE/DE.aspx

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**PARTIAL DIFFERENTIAL EQUATIONS**	
1.1	Formation of partial differential equations by elimination of arbitrary constants and functions.	2
1.2	Solution of standard types of first order PDE.	2
1.3	Lagrange's linear equation – Linear PDE of second and higher order with constant coefficients.	2
2	**Z-Transform**	
2.1	Z - transform of standard functions	2
2.2	Properties of Z-transform	2
2.3	Inverse Z-transform & Convolution Theorem	2
2.4	Introduction to difference operator	1
2.5	Formation and Solution of difference equations.	2
3	**Laplace Transform**	
3.1	Transforms of Standard Functions, Transforms of derivatives and integrals	2

Module No.	Topic	No. of Periods
3.2	Transform of Unit step function and Dirac's delta function - Transforms of Periodic functions	2
3.3	Inverse Laplace transform, Partial Fraction, Convolution Theorem	2
3.4	Method of solving ordinary linear differential equations with constant coefficient and solving integral equations.	2
4	**Fourier Series**	
4.1	Dirichlet's conditions, statement of Fourier theorem	3
4.2	Fourier coefficients, Even and odd functions	2
4.3	change of scale	2
4.4	Half-range sine and cosine series	2
4.5	RMS value, Parseval's theorem	2
5	**Fourier Transform**	
5.1	Fourier integrals - Fourier transform	2
5.2	Fourier sine and cosine transform	2
5.3	Transforms of standard functions - Properties, Convolution theorem	2
5.4	Discrete Fourier and Fast Fourier Transforms	2
5.5	Computation of inverse DFT, properties of DFT	2
	Total	**44**

Course Designer(s):

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23DS320 ABSTRACT ALGEBRA

Category	L	T	P	Credit
FC	4	0	0	4

Preamble

This course will enable students to learn the basic concepts of algebraic structures and groups, apply the concepts of normal subgroups and Cayley's theorem, model the concepts of Coding of Binary information and Error detection and learn the concepts of rings, fields and unique factorization theorem

Prerequisite

Nil

Course Outcomes

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

CO1	Apply the concepts of Groups, subgroups and its properties with Permutation.	Apply
CO2	Apply the concept of groups to learn about normal subgroups and fundamental theorem of group homomorphism	Apply
CO3	Apply the concept of groups to learn about coding of binary information, decoding, error correction and residue arithmetic	Apply
CO4	Apply the concepts of Rings to Learn its properties and different types of rings.	Apply
CO5	Apply the concept of rings to find factorization of polynomials and primitive polynomials	Apply
CO6	Apply the concept of fields to find the structure of finite field and GF	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	M	-	-	-	-	-	-	-	-	L	M
CO2	S	S	M	M	-	-	-	-	-	-	-	-	L	S
CO3	S	S	M	M	-	-	-	-	-	-	-	-	L	S
CO4	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO5	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO6	S	S	L	L	-	-	-	-	-	-	-	-	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	10	20						30																2	5	8			
CO2	4	10	30						35																2	5	16			
CO3	2	10	10						35																2		8			
CO4													4	10	30						35				2	5	14			
CO5													2	10	20						35				2	5	14			
CO6													4		20						30						10			
Total (in %)	100						100						100						100						100					

Syllabus

GROUPS:
Groups - Definition and Example, Properties of Groups, Permutation Groups, Symmetric Groups, Subgroups, Cyclic Groups, Cosets and Lagrange's theorem, Normal subgroups, Isomorphism, Homomorphism, Automorphism, Cayley's theorem, Factor group, Fundamental theorem of group homomorphism.

CODING THEORY AND RESIDUE ARITHMETIC:
Coding of Binary information and Error detection – Group codes – Decoding and Error correction, Overview of Residue arithmetic.

RINGS:
Definition and Properties – Subrings, Ring of Quaternions, Homomorphism, Ideals and Quotient Rings, Integral domain, Euclidean ring - Unique factorization theorem, Polynomials Rings – Properties, Division Algorithm, Factorization of Polynomials – Primitive polynomials.

FIELDS:
Definition – Subfields - Finite fields – Galois Field.

Reference Books and web resources

1. Joseph A. Gallian, "Contemporary Abstract Algebra", Brooks/Cole, 9th edition 2018.
2. Herstein I. N., "Topics in Algebra", John Wiley & Sons, 2012.
3. Tremblay J. P. and Manohar R., "Discrete Mathematical Structures with Applications to Computer Science", Tata McGrawHill, 2017.
4. Ralph P. Grimaldi and Ramana B. V., "Discrete and Combinatorial Mathematics: An Applied Introduction", Pearson Education, 5th edition 2019.
5. https://mathworld.wolfram.com/AbstractAlgebra.html

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	Groups	
1.1	Groups - Definition and Example	1
1.2	Properties of Groups	1
1.3	Permutation Groups, Symmetric Groups	2
1.4	Subgroups	2
1.5	Cyclic Groups	2
1.6	Cosets and Lagrange's theorem	2
1.7	Normal subgroups	1
1.8	Isomorphism	2
1.9	Homomorphism, Automorphism, Cayley's theorem	2
1.10	Factor group – Fundamental theorem of group	2

Module No.	Topic	No. of Periods
	homomorphism	
2	CODING THEORY AND RESIDUE ARITHMETIC:	
2.1	Coding of Binary information and Error detection	2
2.2	Group codes	2
2.3	Decoding and Error correction	2
2.4	Overview of residue arithmetic	3
3	RINGS:	
3.1	Definition and Properties	1
3.2	Subrings, Ring of Quaternions	2
3.3	Homomorphism, Ideals and Quotient Rings	2
3.4	Integral domain, Euclidean ring	2
3.5	Unique factorization theorem, Polynomials Rings – Properties	2
3.6	Division Algorithm, Factorization of Polynomials – Primitive polynomials	**2**
4	FIELDS:	
4.1	Definition	1
4.2	Subfields	2
4.3	Finite fields	2
4.4	Galois Field	2
	Total	**44**

Course Designer(s):

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23DS330 DATA STRUCTURES

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

This course aims at providing a deep understanding of various data structures, their operations and enables the students to identify appropriate data structures and design suitable algorithms for real world user requirements.

Prerequisite

- 23DS140 Problem Solving Using C programming

Course Outcomes

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

CO1	Explain the organization and operations of different data structures with an understanding of their efficiency	Understand
CO2	Demonstrate the operations of linear data structures (Array, Linked list, stack and queues)	Apply
CO3	Demonstrate the operations of non-linear data structures (Trees, Graph)	Apply
CO4	Demonstrate search and sort algorithms with an understanding of their analysis	Apply
CO5	Implement the user requirements by selecting appropriate linear and non-linear data structures	Apply
CO6	Modify the existing operations of data structures for changing needs of the software requirements	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	M	-	-	-	L	L	-	L	M	L
CO2	S	M	M	L	M	-	-	-	L	L	-	L	M	M
CO3	S	M	M	L	M	-	-	-	L	L	-	L	M	M
CO4	S	M	M	L	M	-	-	-	L	L	-	L	M	M
CO5	S	M	S	L	M	-	-	-	L	L	-	L	S	S
CO6	S	S	S	L	M	-	-	-	L	L	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	20																							2	10				
CO2	5		30						50																2	5	10			
CO3													5	20	20						25				2	5	10			
CO4		5	10										5	10											2	5	10			
CO5		5	20						50						20						25				2	5	15			
CO6																20						50						15		
Total (in %)	100						100						100						100						100					

Syllabus

Introduction: Abstraction - Data structures - Abstract Data Types - Primitive data structures – Types of data structures- Analysis of algorithms - Best, worst and average case time complexities - notations.

Arrays and Linked Lists: Data storage and primitive Operations –Singly linked lists, Doubly linked lists, Circular lists - Applications: Addition of Polynomials; Sparse Matrix representation

Stacks: Primitive operations - Sequential implementation – Linked Stacks. Applications - Recursion – Expression Processing

Queues: Primitive operations - sequential implementation - Dequeues – Applications - Linked queues - Dynamic Storage Management.

Trees: Terminologies - Implementation - BINARY TREE: Properties - Sequential and linked representation –Traversals - Expression trees - Infix, Postfix and Prefix expressions - Binary Search Tree -Insertion and deletion – other operations - Need for balancing - AVL trees - Height – searching – insertion and deletion of elements- AVL rotations

Graph: Terminologies – Matrix and list representation – Graph Traversals (DFS & BFS)

Search and Sorting techniques– Linear Search – Binary search - Bubble sort – Selection sort – Insertion Sort – Quick Sort – Merge Sort

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, “Introduction to Algorithms”, Fourth Edition, MIT Press 2022.
2. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Silicon Press, 2011.
3. Aaron M. Tanenbaum, Moshe J. Augenstein and Yedidyah Langsam, "Data structures using C and C++", Prentice Hall, 2012.
4. Mark Allen Weiss, “Data structures and Algorithm Analysis in C++”, Fourth Edition, 2014.
5. Yashavant Kanetkar, “Data Structures Through C++”, 4th Edition, BPB Publications, 2022

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION**	
1.1	**A**bstraction - Data structures - Abstract Data Types	2
1.2	Primitive data structures – Types of data structures	1
1.3	Analysis of algorithms - Best, worst and average case time complexities	1
1.4	Complexity notations	1
2	**Arrays and Linked Lists**	
2.1	Data storage and primitive Operations with arrays	2

Module No.	Topic	No. of Periods
2.2	Singly linked lists	2
2.3	Doubly linked lists	2
2.4	Circular linked lists	1
2.5	Addition of Polynomials	1
2.6	Sparse matrix representation	2
3	**Stacks**	
3.1	Primitive operations - Sequential implementation	2
3.2	Linked Stacks	1
3.3	Recursion	1
3.4	Expression processing	2
4	**Queues**	
4.1	Primitive operations - sequential implementation	2
4.2	Dequeues- Applications	2
4.3	Linked queues	1
4.4	Dynamic storage management	1
5	**Trees**	
5.1	Terminologies - Implementation - BINARY TREE: Properties	1
5.2	Sequential and linked representation	1
5.3	Traversals - Expression trees - Infix, Postfix and Prefix expressions	1
5.4	Binary Search Tree -Search and Insertion	2
5.5	Deletion	1
5.6	Applications of BST	1
5.7	Need for balancing - AVL trees - Height – searching – insertion and deletion of elements- AVL rotations	2
6	**Graph**	
6.1	Terminologies – Matrix and list representation	1
6.2	Graph Traversals (DFS & BFS)	3
7	**Search and Sorting techniques**	
7.1	Linear Search & Binary search	1
7.2	Bubble sort, Selection sort	1
7.3	Insertion sort	1
7.4	Quick sort	1
7.5	Merge Sort	1
	Total	**46**

Course Designer(s):

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23DS340 DATABASE MANAGEMENT

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

This course aims to make it easier for students to comprehend the various DBMS software functionalities and perform numerous operations related to building, modifying, and maintaining databases for real-world applications. It also aims to help students understand various designing concepts, storage solutions, querying methods, and database management.

Prerequisite

Nil

Course Outcomes

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

CO1	Formulate Entity Relationship(ER) and Relational Models for a given application to design a consistent database	Apply
CO2	Develop a normalized database for a given application by incorporating various constraints like integrity and value constraints	Apply
CO3	Manipulate relational database using Structured Query Language and relational languages.	Apply
CO4	Apply data design and storage techniques for a given scenario	Apply
CO5	Construct Database with indexes and hash tables for the fast retrieval of data.	Apply
CO6	Illustrate different transaction and concurrency control mechanisms to preserve data consistency in a multi-user environment.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	L	L	-	-	L	L	-	L	M	M
CO2	S	M	M	L	L	L	-	-	L	L	-	L	M	M
CO3	S	M	M	L	L	L	-	-	L	L	-	L	M	M
CO4	S	M	M	L	M	M	-	-	L	L	-	L	M	M
CO5	S	M	S	L	M	S	-	-	L	L	-	L	M	M
CO6	S	S	S	L	M	S	-	-	L	L	-	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10	15						25																2	5	10			
CO2	5	10	20						25																2	5	15			
CO3		10	25						50					5	15										2	5	15			
CO4														5	15						25				2	10				
CO5													5	10	15						25				2		10			
CO6													5	10		15						50				5		10		
Total (in %)	100						100						100						100						100					

Syllabus

BASIC CONCEPTS: Introduction to databases – Conventional file Processing – Data Modelling for a database – Three level architecture – Data Independency –Components of a Database Management System (DBMS) – Advantages and disadvantages of a DBMS –System Environment – Users of DBMS – Transaction Management.

DATA MODELS: Introduction – Conceptual data modelling – Motivation - Entities, entity types, various types of attributes, relationships, relationship types - E/R Diagram(ERD) notation - Generalization– Aggregation – Conversion of ERD into relational schema – Introduction to Network data model and Hierarchical data model.

RELATIONAL DATA MODEL: Introduction – Keys, relational algebra operators: selection, projection, cross product, various types of joins, division, examples, tuple relation calculus, domain relational calculus.

RELATIONAL DATABASE MANIPULATION: Structured Query Language (SQL) - Basic data retrieval –nested queries - correlated and uncorrelated - SQL Join – Views.

DATABASE DESIGN THEORY: Functional dependencies – Normal forms - Dependency theory – Armstrong's axioms for FDs - Closure of a set of FDs, Minimal covers– 1NF, 2NF, 3NF and BCNF - Join dependencies and definition of 5NF – Examples.

DATA STORAGE AND INDEXING: Storage device Characteristics – Operations on file - Sequential files - Index Sequential files – Direct files – Indexing using Tree structures.

DATABASE SECURITY, INTEGRITY AND CONTROL: Security and Integrity threats – Defence mechanisms - Transaction processing – concepts - ACID properties - concurrency control - recovery methods.

Reference Books

1. Silberschatz A., Korth H. and Sudarshan S., “Database System Concepts”,7th edition McGraw Hill, 2021.
2. Elmasri R. and Navathe S.B., “Fundamentals of Database Systems”, Pearson Education, 2017.
3. Raghu Ramakrishnan and Johannes Gehrke, “Database Management System”, McGraw Hill, 2017.
4. Bipin C.Desai, “An Introduction to Database System”, Galgotia Publishers, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Basic Concepts**	
1.1	Introduction to databases and conventional file processing	1
1.2	Data modelling for a database	2
1.3	Three-level architecture	1
1.4	Data independency	1
1.5	Components of a DBMS,Advantages and disadvantages of a DBMS	1
1.6	System environment & users of DBMS	1
1.7	Transaction management	1
2	**Data Models**	

Module No.	Topic	No. of Periods
2.1	Introduction	1
2.2	Conceptual data modelling and motivation	2
2.3	Entities, entity types, various types of attributes, relationships, relationship types	2
2.4	E/R Diagram notation	1
2.5	Generalization and aggregation	1
2.6	Conversion of ERD into relational schema	1
3	**Relational Data Model**	
3.1	Introduction	1
3.2	Keys	1
3.3	Relational algebra operators: selection, projection, cross product, various types of joins, division, examples	2
3.4	Tuple relation calculus, domain relational calculus	2
3.5	Network data model and Hierarchical data model	1
4	**Relational Database Manipulation**	
4.1	Structured Query Language (SQL) - Basic data retrieval	1
4.2	Nested queries - correlated and uncorrelated	1
4.3	SQL Join – Views	1
5	**Database Design Theory**	
5.1	Functional dependencies	1
5.2	Normal forms	2
5.3	Dependency theory and Armstrong's axioms for FDs	2
5.4	Closure of a set of FDs, minimal covers	3
5.5	1NF, 2NF, 3NF and BCNF Join dependencies and definition of 5NF	3
6	**Data Storage and Indexing**	
6.1	Storage device characteristics	1
6.2	Operations on file	1
6.3	Sequential files	1
6.4	Index Sequential files, direct files, indexing using Tree structures	1
7	**Database Security, Integrity and Control**	
7.1	Security and integrity threats	1
7.2	Defence mechanisms	1
7.3	Transaction processing concepts, ACID properties, concurrency control, recovery methods	2
	Total	**46**

Course Designer(s):

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23DS350 OPERATING SYSTEMS

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

The objective of this course is to introduce basic principles of operating systems which include memory management, device management, process management, file management and security & protection mechanisms with case studies from Windows and Linux operating systems.

Prerequisite

NIL

Course Outcomes

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

CO1	Describe the evolution, types, structure, and functions of operating systems	Understand
CO2	Demonstrate the process management functionalities of operating systems including threads, inter process communication and scheduling	Apply
CO3	Provide solutions for process synchronization and deadlocks	Analyze
CO4	Demonstrate the different memory management policies with paging, segmentation, and virtual memory schemes	Apply
CO5	Determine the mechanisms adopted for I/O and file systems in user applications	Apply
CO6	Execute Linux basic commands and shell scripts	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	L	-	-	-	L	L	-	L	L	L
CO2	S	M	M	L	L	L	-	-	L	L	-	L	L	L
CO3	S	S	S	L	L	L	-	-	L	L	-	M	L	L
CO4	S	M	M	L	L	L	-	-	L	L	-	L	L	L
CO5	S	M	M	L	L	L	-	-	L	L	-	L	L	M
CO6	S	M	S	L	S	L	-	-	L	L	-	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10																							2	5				
CO2	10	10	20						50																2	5	15			
CO3			20	20						50															2	5		15		
CO4													10	10	20						50				2	5	15			
CO5													10	10	20						25				2	5	10			
CO6															20						25						10			
Total (in %)	100						100						100						100						100					

Syllabus

Introduction: Need of Operating system, Operating system- Operations, functionalities, computing environments – Operating System structures

Process Management: Process states — Operations on process – Inter process communication - Thread concepts - Processor Scheduling – Implementation of scheduler - Case studies

Process Synchronization - Semaphores, Shared memory multiprocessors, Alternative Synchronization primitives, Monitors, Classical Synchronization problems, Implementation - Bounded Buffer Problem, Reader's Writer's Problem, Dining Philosopher's Problem - Deadlock prevention, avoidance, detection and recovery.

Memory Management: Swapping, Paging, Segmentation, Virtual Memory — Demand paging, Page Replacement algorithms – Implementation of algorithms

File & Storage Management: File System concepts and access methods, File structure, Allocation methods, free space management, Disk Structure, Disk Scheduling.

Linux Programming - Command Line and Shell Scripting Basics.

Reference Books

1. Abraham Silberschatz, Greg Gagne, Peter B. Galvin, "Operating System Concepts", 9th edition, Wiley, 2013.
2. Andrew Tanenbaum, Herbert Bos, "Modern Operating Systems", Fifth Edition, Pearson Education, 2014
3. William Stallings, "Operating systems Internal and Design Principle", Ninth Edition, Pearson Education, 2015
4. Carl Albing, Vossen, "bash Cookbook: Solutions and Examples for bash Users", 2nd Edition, O'Reilly, 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION**	
1.1	Need of Operating system, Operating system- Operations	2
1.2	Functionalities - computing environments	1
1.3	Operating System structure	1
2	**Process Management**	
2.1	Process states — Operations on process	1
2.2	Interprocess communication	1
2.3	Thread concepts	1
2.4	Processor Scheduling - implementation	2
3	**Process Synchronization**.	
3.1	Semaphores	2

Module No.	Topic	No. of Periods
3.2	Shared memory multiprocessors, Alternative Synchronization primitives	1
3.3	Monitors, Classical Synchronization problems,	2
3.4	Implementation - Bounded Buffer Problem, Reader's Writer's Problem, Dining Philosopher's Problem	2
3.5	Deadlock prevention, avoidance, detection and recovery	2
4	**Memory Management**	
4.1	Swapping techniques	1
4.2	Paging	2
4.3	Segmentation	1
4.4	Virtual Memory — Demand paging	1
4.5	Page Replacement algorithms – Implementation of algorithms	2
5	**File & Storage Management**	
5.1	File System & access methods	2
5.2	Allocation methods	1
5.3	Free space management	1
5.4	Disk Structure, Disk Scheduling	2
6	**Linux Programming**	
6.1	Command Line Basics.	2
6.2	Shell Scripting	2
	Total	**35**

Course Designer(s):

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Dept. of Applied Mathematics and Computational Science

		Category	L	T	P	Credit
23DS370	**DATA STRUCTURES LAB**	PCC	0	0	4	2

Preamble

The objective of this lab is to provide hands-on experience to implement the algorithms for performing various operations on data structures. Students will gain practical knowledge by writing and executing programs in C++ using various data structures such as arrays, linked lists, stacks, queues, trees, graphs and search trees.

Prerequisite

- 23DS170 C Programming Lab
- 23DS280 Object Oriented Programming Lab

Course Outcomes

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

CO1	Design algorithms for the given problem specifications by choosing appropriate data structures and relevant operations.	Apply
CO2	Implement programs for the given algorithm specification using data structures	Apply
CO3	Implement programs to implement linear data structures: Stack and Queue using arrays and linked list in an application context.	Apply
CO4	Implement non-linear data structures: Graph, Trees in an application context	Apply
CO5	Implement algorithms that use sorting and searching as sub-procedures.	Apply
CO6	Prepare laboratory reports for the applications developed	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1:	S	M	L	-	-	M	-	-	L	-	-	-	M	M
CO2:	S	M	L	-	-	M	-	-	L	-	-	-	M	M
CO3:	S	M	L	-	-	M	-	-	L	-	-	-	M	M
CO4:	S	M	L	-	-	M	-	-	L	-	-	-	M	M
CO5:	S	M	L	-	-	M	-	-	L	-	-	-	M	M
CO6:	S	M	L	-	-	M	-	-	L	-	-	-	M	M

S- Strong; M-Medium; L-Low

List of Experiments

1. Search algorithms (Linear Search and Binary Search) using Arrays.
2. Sorting algorithms (Bubble/Insertion/Selection and Merge/Quick) using Arrays.
3. Implementation of Singly, Doubly and Circular Linked Lists
4. Stack implementation and Two-way stack implementation
5. Expression evaluation using a Stack
6. Implementation of Queue, Circular Queue
7. Binary Trees and traversals
8. Graph representation and traversal
9. Use of Data Structure libraries in the language

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson, and Ronald L'Rivest, “Introduction to Algorithms”, Fourth Edition, MIT Press, 2022.
2. H.M. Deitel and P.J. Deitel, C “How to program Introducing C++ and Java”, Fourth Edition, Pearson Prentice Hall, (2012),Reprint 2020.
3. Reema Thareja “Computer fundamentals and programming in c”, Oxford University, Second edition, 2017

Course Designer(s):

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23DS380 RELATIONAL DATABASE LAB

Category	L	T	P	Credit
PCC	0	0	4	2

Preamble

This course aims to provide students with considerable knowledge to database design and E-R modelling. This course also provides students with hands-on training in SQL and programming languages that extend SQL.

Prerequisite

Nil

Course Outcomes

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

CO1	Model Entity Relationship with E-R diagrams for given application specification.	Apply
CO2	Design database schema considering normalization and relationships within database.	Apply
CO3	Write SQL queries to user specifications and design the queries that are scalable and optimised.	Apply
CO4	Develop triggers, procedures, user defined functions and design PLSQL programs in Databases	Apply
CO5	Use the database for a real world application and connect it from a front end application.	Apply
CO6	Use PL/SQL procedures for a solving a programming logic and develop package for database.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	S	S	L	-	L	-	-	-	-	-	-	-	M	L
CO2.	S	S	L	-	L	-	-	-	-	-	-	-	M	L
CO3	S	S	S	-	S	-	-	-	-	-	-	-	M	L
CO4	S	S	S	-	S	-	-	-	-	-	-	-	M	L
CO5.	S	S	S	-	S	-	-	-	-	-	-	-	M	L
CO6	S	M	M	-	S	-	-	-	-	-	-	-	M	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Model ER diagram based on given project specifications
2. Design normalized relational database design on given project specification
3. SQL DDL-Create a SQL DDL Queries for a specific application.
4. SQL DML-Insert values into the Tables and Manipulate the data in it using DML commands.(Aggregate functions, Subqueries, Joins, Nested tables, Views)
5. PL/SQL Programming Procedures and functions
6. Implementation of Cursors.
7. Implementation of Triggers.
8. DCL and TCL commands
9. Development of front end application that connects with a database

Reference Books

1. Silberschatz A., Korth H. and Sudarshan S., “Database System Concepts”, McGraw Hill, 2021.
2. Elmasri R. and Navathe S.B., “Fundamentals of Database Systems”, Pearson Education, 2017.
3. Raghu Ramakrishnan and Johannes Gehrke, “Database Management System”, McGraw Hill, 2017.
4. Bipin C.Desai, “An Introduction to Database System” , Galgotia Publishers, 2012.

Course Designer(s):

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		Category	L	T	P	Credit
23DS410	**LINEAR ALGEBRA**	FC	4	0	0	4

Preamble

This course will enable students to solve the given system of linear equations through matrices, compute Eigen values, Eigen vectors and model to a quadratic form and construct a singular value decomposition for the given matrix, also perform diagonalization of a given matrix, verify whether the given set is a vector space or not, determine the matrix for the given linear transformation.

Prerequisite

Nil

Course Outcomes

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

CO1:	Apply the concept of Gauss elimination in solving linear equations and to find the inverse of a matrices	Apply
CO2:	Apply the concept of Eigen values and vectors to orthogonal diagonalizing a given matrix,	Apply
CO3:	Diagonalize a given matrix from quadratic form	Apply
CO4:	Apply the concept of vector spaces, linear independence, basis and dimensions to find Rank	Apply
CO5:	Apply the concept of linear transformation in matrices and geometry linear operators	Apply
CO6:	Apply the concepts of Inner product spaces and orthogonal projections to find QR decomposition and least squares	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO3.	L	L	L	M	-	-	-	-	-	-	-	-	L	M
CO4.	S	S	M	M	-	-	-	-	-	-	-	-	L	S
CO3	S	S	M	M	-	-	-	-	-	-	-	-	L	S
CO4	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO5	S	S	M	S	-	-	-	-	-	-	-	-	L	S
CO6	S	S	L	L	-	-	-	-	-	-	-	-	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	2		20						30																	5	8			
CO2	4	10	20						35																2	5	10			
CO3	4	10	30						35																2		15			
CO4													4	10	30						35				2	5	12			
CO5													4		20						30				2		10			
CO6													2	10	20						35				2	5	15			
Total (in %)	100						100						100						100						100					

Syllabus

SYSTEM OF LINEAR EQUATIONS AND MATRICES:

System of linear equations, Gauss Elimination, Gauss – Jordan, Inverse of a matrix Using Gauss - Jordan.

EIGEN VALUES AND EIGEN VECTORS:

Introduction toEigen values and Eigen Vectors - Diagonalizing a matrix – Similarity and Orthogonal diagonalization – Applications of Eigen value problems – Quadratic forms

VECTOR SPACES:

Vector spaces and subspaces — Linear combination, Span, Linearindependence and dependence - Basis andDimension of a vector space - Change of basis.

LINEAR TRANSFORMATION:

Introduction to linear transformations — General Linear Transformations – Null space and Range – Rank and nullity – Row space and Column space - Matrices of general linear transformation.

INNERPRODUCT SPACES:

Inner product, Length, angle and orthogonality – Orthogonal sets – Orthogonal projections — Inner product spaces — Orthonormal basis: Gram-Schmidt process — QR Decomposition - Best Approximation, Least-squares.

Reference Books and Web Resources

1. David C. Lay, “Linear Algebra and its Applications", Pearson Education, 6th edition 2021.
2. Howard Anton and Chris Rorres, “Elementary Linear Algebra”, Wiley, 12th edition 2019.
3. Gilbert Strang, “Linear Algebra and its Applications”, Thomson Learning, 5th edition, 2016.
4. Steven J. Leon, “Linear Algebra with Applications”, Prentice Hall, 10th edition, 2021.
5. https://ilasic.org/
6. https://www.khanacademy.org/math/linear-algebra
7. https://mathworld.wolfram.com/topics/LinearAlgebra.html

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	SYSTEM OF LINEAR EQUATIONS AND MATRICES:	
1.1	System of linear equations	1
1.2	Gauss Elimination	2
1.3	Gauss – Jordan	2
1.4	Inverse of a matrix using Gauss - Jordan	2
2	EIGEN VALUES AND EIGEN VECTORS:	
2.1	Introduction to Eigen values and Eigen Vectors	2
2.2	Diagonalizing a matrix	2

Module No.	Topic	No. of Periods
2.3	Similarity and Orthogonal diagonalization	2
2.4	Applications of Eigen value problems	1
2.5	Quadratic forms	2
3	VECTOR SPACES:	
3.1	Vector spaces and subspaces	2
3.2	Linear combination, Span, Linear independence and dependence	3
3.3	Basis and Dimension of a vector space	2
3.4	Change of basis.	2
4	LINEAR TRANSFORMATION:	
4.1	Introduction to linear transformations	1
4.2	General Linear Transformations	1
4.3	Null space and Range, Rank and nullity	2
4.4	Row space and Column space	2
4.5	Matrices of general linear transformation.	2
5	INNER PRODUCT SPACES:	
5.1	Inner product, Length, angle and orthogonality	2
5.2	Orthogonal sets – Orthogonal projections	2
5.3	Inner product spaces	1
5.4	Orthonormal basis: Gram-Schmidt process	2
5.5	QR Decomposition - Best Approximation	2
5.6	Least-squares	2
	Total	**44**

Course Designer:

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23DS420	PREDICTIVE ANALYTICS	Category	L	T	P	Credit
		PCC	4	0	0	4

Preamble

This course will enable students to apply specific statistical and regression analysis methods to develop and use various regression and classification predictive models and perform time series analysis with suitable techniques

Prerequisite

- 23DS220- Applied Statistics

Course Outcomes

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

CO1	Demonstrate simple linear regression models with appropriate validation of the models	Apply
CO2	Develop multiple linear regression models with appropriate validation of the models	Analyze
CO3	Formulate methods to improve linear regression models by addressing different data conflicts	Apply
CO4	Develop logistic regression models with appropriate validation of the models	Analyze
CO5	Demonstrate the application of decision trees in classification and regression	Apply
CO6	Perform time series analysis and forecasting using smoothing, moving average and different auto regressive models	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	M	-	-	L	L	L	-	L	S	S
CO2	S	S	M	M	M	L	L	L	L	L	-	L	S	S
CO3	S	S	M	S	M	L	L	L	L	L	-	L	S	S
CO4	S	S	M	M	M	L	L	L	L	L	-	L	S	S
CO5	S	M	M	M	M	L	L	L	L	L	-	L	S	S
CO6	S	M	M	M	M	L	L	L	L	L	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10	20																						2		15			
CO2	5	10	10	20						50															2	5		10		
CO3		10	10						50																2	5	10			
CO4													5	5	5	20						50			2	5	10	5		
CO5													5	5	25						25				2		10			
CO6														10	20						25					5	10			
Total (in %)	100						100						100						100						100					

Syllabus

SIMPLE LINEAR REGRESSION(SLR): Correlation analysis, Model building, Estimation and interpretation of coefficients, Validation of SLR model, Coefficient of determination, Significance test, Residual analysis, Outlier analysis, Confidence and Prediction intervals.

MULTIPLE LINEAR REGRESSION(MLR): Model building, Estimation and interpretation of coefficients, Validation of MLR model: Adjusted R square, Bias and Variance, Underfitting and overfitting, Crossvalidation, Categorical variables, heteroscedasticity, Multi-collinearity and Variance Inflation Factor, Auto correlation, Outlier analysis, Feature selection and transformations, Regularization

LOGISTIC AND MULTINOMIAL REGRESSION: Logistic function, Estimation of probability using Logistic regression, Model validation:Wald Test, Hosmer Lemshow Test, Classification Table and ROC curve, Feature selection, Multinomial Logistic regression

DECISION TREES : Introduction,Gini Impurity index and Entropy, Classification and Regression trees

TIME SERIES ANALYSIS: Time-series data components, Forecasting techniques, Moving average, Exponential Smoothing: Single, Double and Triple, Regression model for forecasting, Autoregressive Models-AR,MA,ARMA, ARIMA models.

CASE STUDIES

Reference Books and web resources

1. Anderson, Sweeney and Williams, “Statistics for business and economics”, Cengage Learning, 13th Edition, ,2018
2. Trevor Hastie, Robert, Jerome, “The elements of statistical learning: Datamining, Inference and Prediction”, 2nd Edition, 2017.
3. Eric Seigel, “Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die”, 2016
4. Ronald E. Walpole, Raymond H. Meyers, Sharon L. Meyers, “Probability and Statistics for Engineers and Scientists”, Pearson Education, 9th Edition, 2022
5. U. Dinesh Kumar, ”Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017
6. Introduction to Predictive Modeling – Coursera

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**SIMPLE LINEAR REGRESSION(SLR)**:	
1.1	Correlation analysis	1
1.2	Model building, Estimation and interpretation of coefficients,	2
1.3	Coefficient of determination, Significance Testing	2
1.4	Residual analysis	2
1.5	Outlier analysis	1
1.6	Confidence and Prediction intervals	2

Module No.	Topic	No. of Periods
2	**MULTIPLE LINEAR REGRESSION**	
2.1	Model building, Estimation and interpretation of coefficients	2
2.2	Validation of MLR model: Adjusted R square , Bias and Variance, Underfitting and overfitting, cross validation techniques	2
2.3	Categorical variables, heteroscedasticity, Multi-collinearity and Variance Inflation Factor	2
2.4	Auto correlation	1
2.5	Outlier analysis	1
2.6	Feature selection and transformations, Regularization	2
3	**LOGISTIC AND MULTINOMIAL REGRESSION**	
3.1	Logistic function, Estimation of probability using Logistic regression	1
3.2	Wald test	2
3.3	Hosmer Lemshow Test	1
3.4	Classification Table and ROC curve	2
3.5	Feature selection, Multinomial Logistic regression	2
4	**DECISION TREES**	
4.1	Gini Impurity index and Entropy	3
4.2	Classification decision trees	2
4.3	Regression trees	2
5	**TIME SERIES ANALYSIS**	
5.1	Time-series data components	1
5.2	Forecasting techniques, Moving average,	1
5.3	Exponential Smoothing: Single, Double and Triple	2
5.4	Regression model for forecasting	2
5.5	AR,MA,ARMA, ARIMA models	2
5.6	Case Studies	2
	Total	**45**

Course Designer(s):

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		Category	L	T	P	Credit
23DS430	**DESIGN AND ANALYSIS OF ALGORITHMS**	PCC	3	1	0	4

Preamble

This course will enable students to solve a given problem using an algorithm. Also, it enables them to mathematically analyze the algorithms for its efficiency and effectiveness for choosing a better solution to real time algorithmic problems.

Prerequisite

- 23DS330 Data Structures

Course Outcomes

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

CO1	Summarize the relevance of algorithms for computational problems solving and real time applications.	Understand
CO2	Differentiate different algorithmic approaches, techniques and methods.	Understand
CO3	Apply paradigms like divide and conquer, greedy and dynamic programming for a given algorithm.	Apply
CO4	Apply optimization techniques for improving the efficiency of graph-based algorithms to solve complex problems.	Apply
CO5	Analyze the worst-case, best-case and average-case running time of algorithms using asymptotics.	Analyze
CO6	Evaluate polynomial reductions for standard problems with an understanding of the intractable complexity classes like NP- Complete and NP-hard.	Evaluate

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO2	S	M	-	-	-	-	-	-	-	-	-	-	L	L
CO3	S	S	-	-	-	-	-	-	-	-	-	-	L	L
CO4	S	S	M	-	-	L	L	-	-	-	-	-	L	L
CO5	S	S	L	-	-	-	-	-	-	-	-	-	L	L
CO6	S	S	L	-	-	-	-	-	-	-	-	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10																							2	10				
CO2	10	10							30																2	10				
CO3		10	30						30																2		20			
CO4									40				5	10	20										2		20			
CO5	5			20									5	10		20						50			2	5		10		
CO6														10	10		10					50				5			10	
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION: Fundamentals of algorithmic problem solving - Methods of specifying an algorithm – proving the correctness – analyzing an algorithm, Asymptotic notations, Recurrences – Master theorem.

DIVIDE AND CONQUER: Integer multiplication, matrix multiplication

GREEDY METHOD: Minimum cost spanning tree (Kruskal and Prim‟s algorithms), topological sorting, Huffman codes and data compression.

DYNAMIC PROGRAMMING: Principles of dynamic programming – 0/1 knapsack problem, all pairs shortest problem, travelling salesman problem.

GRAPHS: Definition – Representations– Network representation, shortest path- Dijkstra's algorithm, Graph search methods (Breadth first and depth first traversals)- Applications of depth first search- Biconnectivity.

NP AND COMPUTATIONAL INTRACTABILITY: Basic concepts – Polynomial time reductions, efficient certification and NP, NP hard and NP complete problems.

COPING WITH NP-COMPLETENESS: Backtracking-n queen's problem, Graph coloring problem - Branch and bound - 0/1 knap sack problem, traveling salesman problem, Approximation algorithm.

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson, and Ronald LRivest, —Introduction to Algorithms, Fourth Edition, MIT Press, 2022. (Chapters: 1 to 5, 15, 16, 17, 34 & 35).
2. M.A.Weiss, "Data Structures and Algorithm Analysis in C++", Pearson Education Asia, 2013.
3. Jon Kleinberg and Eve Tardos, "Algorithm Design", Pearson Education, 2012
4. Anany Levitin, "Introduction to Design and Analysis of Algorithms", Pearson Education, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	1
1.1	Fundamentals of algorithmic problem solving	1
1.2	Methods of specifying an algorithm	1
1.3	proving the correctness	1
1.4	analyzing an algorithm	1
1.5	Asymptotic notations	1
1.6	Recurrences	1
1.7	Master theorem	2
2	**Divide and Conquer Method (DCM)**	
2.1	Introduction to DCM	1

Module No.	Topic	No. of Periods
2.2	Integer Multiplication	1
2.3	Matrix multiplication	1
3	**Greedy Method**	
3.1	Minimum cost spanning tree (Kruskal and Prim's algorithms)	2
3.2	Topological sorting	1
3.3	Huffman codes	2
3.4	Data compression	1
4	**Dynamic programming**	
4.1	Principles of Dynamic programming	1
4.2	0/1 knapsack problem	1
4.3	All pairs shortest problem	1
4.4	Travelling salesman problem	1
5	**Graphs**	
5.1	Definition and Representations	1
5.2	Network representation	1
5.3	Shortest path- Dijkstra's algorithm	2
5.4	Graph search methods (Breadth first and depth first traversals)	2
5.5	Applications of depth first search	1
5.6	Biconnectivity.	1
6	**NP and Computational Intractability**	
6.1	Basic concepts	1
6.2	Polynomial time reductions	1
6.3	Efficient certification and NP	1
6.4	NP hard problem	1
6.5	NP complete problems	1
7	**Coping with NP Completeness**	
7.1	Backtracking	1
7.2	N queen's problem	1
7.3	Graph coloring problem	2

Module No.	Topic	No. of Periods
7.4	branch and bound	1
7.5	0/1 knap sack problem	1
7.6	Travelling salesman problem	2
7.7	Approximation algorithm	1
	Total	**44**

Course Designer:

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23DS440	ADVANCED DATA STRUCTURES	Category	L	T	P	Credit
		PCC	4	0	0	4

Preamble

This course aims at facilitating the student to understand the various advanced data structures, their operations and apply them in real world problems.

Prerequisite

- 23DS330 Data Structures

Course Outcomes

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

CO1	Demonstrate the operations of Balanced Binary search trees and related applications	Apply
CO2	Implement algorithms for Multiway Search Trees	Apply
CO3	Explain the concept of Multi-dimensional Search Trees	Understand
CO4	Implement Priority Queues with Binary heaps	Apply
CO5	Show the avoidance of collisions in the hash tables using collision resolution techniques including open and closed hashing techniques.	Apply
CO6	Explain the implementation of priority queues with leftist heaps and binomial heap	Understand
CO7	Implement suitable technique and algorithms for disjoint set operations	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	L	M	-	-	L	L	-	L	M	L
CO2	S	M	L	L	L	M	-	-	L	L	-	L	M	L
CO3	S	-	L	L	-	-	-	-	-	-	-	-	M	L
CO4	S	M	L	L	L	M	-	-	L	L	-	M	M	L
CO5	S	M	L	L	L	M	-	-	L	L	-	M	M	L
CO6	S	-	L	L	-	-	-	-	-	L	-	M	M	L
CO7	S	M	L	L	L	M	-	-	L	L	-	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10		20						50																		15			
CO2	5	20	20						50																5		10			
CO3	5	20																							5	5				
CO4													5	10	20						30						15			
CO5													5		20						40					5	15			
CO6													5	10											5	5				
CO7														5	20						30						15			
Total (in %)	100						100						100						100						100					

Syllabus

Balanced Binary Search Trees: – Binary Search Tree - Red Black Tree –Splay Tree

Hash Table: Hash function – Separate chaining – Open addressing – Linear probing – Quadratic probing – Double hashing – rehashing

Priority Queues (Heaps): Binary Heaps- Leftist Heaps - Property and operations- Binomial heap, Fibonacci Heap

Multiway Search Trees: B-Tree, - B+ trees, B*-trees, Tries, Application on Tries: Pattern Searching, String matching, Digital search trees, Dictionary applications

Multidimensional Search Trees: Range search–k-d trees- Quad trees.

Disjoint Sets: Disjoint set operations-linked list representation of disjoint sets, disjoint set forests, tree representation, union by rank – Applications of disjoint sets

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson and Ronald L. Rivest, “Introduction to Algorithms”, Fourth Edition, MIT Press, 2022.
2. Karumanchi Narasimha , “Data Structures and Algorithms Made Easy”, 2016
3. Devraj Ganguly, “ Introduction To Data Structures And Algorithms: A Conceptual Guide”, 2021

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Balanced Binary Search Trees**	
1.1	Binary Search Tree	1
1.2	Red Black Tree	2
1.3	Splay Tree	2
	Practice Problems	2
2	**Hash Table:**	
2.1	Hash function	1
2.2	Separate chaining	1
2.3	Open addressing	1
2.4	Linear probing, Quadratic probing	1
2.5	Double hashing	2
2.6	Rehashing	1
	Practice Problems	2
3	**Priority Queues (Heaps):**	

Module No.	Topic	No. of Periods
3.1	Binary Heaps – property and operations	1
3.2	Leftist Heaps- property and operations	2
3.3	Binomial heap – property and operations	2
3.4	Fibonacci Heap – property and operations	2
	Practice Problems	2
4	**Multiway Search Trees:**	
4.1	B-Tree	1
4.2	B+ Tree	1
4.3	B* Tree	1
4.4	Tries	1
4.5	Application on Tries:,	1
4.6	Pattern Searching and String Matching	1
4.7	Digital search trees and Dictionary applications	1
	Practice Problems	2
5	**Multidimensional Search Trees:**	
5.1	k-d trees	1
5.2	Quad trees	1
	Practice Problems	2
6	**Disjoint Sets:**	
6.1	Disjoint set operations	1
6.2	Linked list representation of disjoint sets	1
6.3	Disjoint set forests -tree representation	1
6.4	Union by rank, Applications of Disjoint sets	1
	Practice Problems	2
	Total	**44**

Course Designer(s):

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		Category	L	T	P	Credit
23DS450	**SOFTWARE ENGINEERING**	PCC	3	0	0	3

Preamble

This course will provide knowledge of software engineering discipline, to analyze risk in software design and quality, to introduce the concept of advance software methodology and to plan, design, develop and validate the software project.

Prerequisite

NIL

Course Outcomes

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

CO1: Identify appropriate process models in the software industry according to given circumstances	Understand
CO2: Demonstrate the concepts of DevOps and mastering aspects of software development and automated building.	Understand
CO3: Apply Project Management and Requirement analysis principles to S/W project development.	Apply
CO4: Develop Design models in software engineering effectively, the architecture, the user interface, and the component level.	Apply
CO5: Analyze the cost estimate and problem complexity using various estimation techniques	Analyze
CO6: Generate test cases using the techniques involved in selecting: (a) White Box testing (b) Block Box testing	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	L
CO2	M	L	-	-	-	M	-	-	-	-	-	-		L
CO3	S	M	L	-	-	-	-	S	-	-	-	-	L	L
CO4	S	M	L	-	-	-	-	-	S	-	-	-	L	
CO5	S	S	M	-	-	-	-	-	-	-	-	-	L	
CO6	S	S	M	-	-	-	-	-	-	M	-	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10						20																	10					
CO2	10	10						20																		10				
CO3			60						60																	10	20			
CO4													10		20						40						20			
CO5														10		30						30				5		10		
CO6																30						30				5		10		
Total (in %)	100						100						100						100						100					

Syllabus

Software engineering - Process framework - Umbrella activities. Software process models - Waterfall - Prototyping - evolutionary process model - Agile model - Scrum Teams and Artifacts - Sprint Planning Meeting - Daily Scrum Meeting - Sprint Review Meeting - DevOps. **Requirements Engineering** - Inception - Elicitation - Elaboration - Negotiation - Specification - Validation. Requirements Management - Identifying Stakeholders - Non-functional Requirements - Traceability. Requirements Gathering - Collaborative Requirements Gathering - Usage Scenarios - Elicitation Work Products - Developing Use Cases -Building the Analysis Model - Elements of the Analysis Model - Validating Requirements.

Requirements modelling - Business Use Case, Class-Based Modelling - Functional Modelling - Behavioral Modelling. Design concepts

Design model - Software Architecture - User Experience Design - Mobile App design. Software costs estimation. Software Quality Assurance.

Software testing - Black Box - White Box - Unit - Integration - System - Validation.

Reference Books

1. Roger Pressman, Software Engineering: A Practitioners Approach, (9th Edition), McGraw Hill, 2020. Chapters 1,2,3, 7, 8, 9, 10, 12, 13, 17, 19, 20, 25.
2. Ian Somerville, Software Engineering, 10th edition, Pearson, 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Software**	
1.1	Software Engineering- Process framework	1
1.2	Umbrella activities.	1
1.3	Software process models	1
2	**Life Cycle Models**	
2.1	Water fall, incremental, spiral,	2
2.2	WINWIN spiral,	1
2.3	evolutionary, prototyping	2
2.4	Agile Process Models, Scrum Teams and Artifacts - Sprint Planning Meeting - Daily Scrum Meeting - Sprint Review Meeting	2
2.5	Devops	1
3	**Requirements Engineering tasks**	

Module No.	Topic	No. of Periods
3.1	Inception - Elicitation - Elaboration	2
3.2	Negotiation - Specification - Validation	2
3.3	Requirements Management - Identifying Stakeholders -	2
3.4	Non-functional Requirements - Traceability.	2
3.5	Collaborative Requirements Gathering	1
3.6	Usage Scenarios - Elicitation Work Products	1
3.7	Developing Use Cases -Building the Analysis Model	1
3.8	Elements of the Analysis Model - Validating Requirements.	2
4	**Requirements modelling**	
4.1	Business Use Case	1
4.2	Class-Based Modelling	1
4.3	Functional Modelling	1
4.4	Behavioral Modelling	1
5	**Design concepts**	
5.1	Software Architecture	1
5.2	User Experience Design	1
5.3	Software costs estimation	1
5.4	Software Quality Assurance	1
6	**Software testing**	
6.1	Black Box - White Box	1
6.2	Unit - Integration -	1
6.3	System-Validation.	1
	Total	35

Course Designer(s):

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		Category	L	T	P	Credit
23DS470	**PREDICTIVE ANALYTICS LAB**	PCC	0	0	4	2

Preamble

This course will provide a practical application of specific statistical and regression analysis methods to develop and use various regression and classification predictive models and perform time series analysis with suitable techniques based on the real time requirements

Prerequisite

- 23DS270 Python Programming And Applied Statistics Lab

Course Outcomes

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

CO1	Implement linear regression models with appropriate data collection, pre-processing and postprocessing techniques	Apply
CO2	Implement logistic regression models with appropriate data collection, pre-processing and postprocessing techniques	Apply
CO3	Implement decision trees algorithms for classification and regression	Apply
CO4	Perform time series analysis and forecasting using different auto regressive models	Apply
CO5	Design a project or research presentation with an identified societal problem in a team	Create
CO6	Write technical reports for the tasks performed	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO2	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO3	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO4	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO5	S	S	S	S	S	S	S	S	S	S	S	S	S	S
CO6	-	-	-	-	L	L	L	M	S	L	-	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

Experiments shall be done on data available on Universal repositories / self-collected survey data in Python/R

- Implement and validate Simple Linear regression after appropriate data collection and pre-processing
- Implement and validate Multi Linear regression after appropriate data collection and pre-processing with appropriate testing for multicollinearity (with categorical variables

- Implement and validate Logistic regression
- Implement cross validation in the results obtained for Linear and logistic regression
- Implementing improved performance measures in the results obtained for Linear and logistic regression (Features subset selection, Regularization)
- Implementing Decision trees for classification and regression
- Time Series analysis with moving average and smoothing methods
- Time Series analysis with ARIMA
- Mini project / Research work presentation processing real world user requirements/ research requirements and implementing the same.

Reference Books and web resources

1. Wes McKinney, “Python for Data Analysis”, Oreilly, 3rd Edition, 2022
2. Alvaro Fuentes, “Hands-On Predictive Analytics with Python: Master the complete predictive analytics process, from problem definition to model deployment”, Packt, 2018
3. Basic Data Processing and Visualization – Coursera
4. Data Analysis with R Specialization – Coursera

Course Designer(s):

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23DS480 JAVA PROGRAMMING LAB

Category	L	T	P	Credit
PCC	0	0	6	3

Preamble

This course will help the students how to use the Java programming language constructs to create solutions for problems in the real world and develop Java programs for user defined specifications.

Prerequisite

- 23DS280 Object Oriented Programming Lab

Course Outcomes

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

CO1	Develop Java programs using OOP Principles and proper program structuring.	Apply
CO2	Develop Java programs to implement exception handling and Multithreading applications.	Apply
CO3	Implement Java programs using packages, Streams, interfaces and collection classes	Apply
CO4	Use API that allows Java program to access the database management systems.	Apply
CO5	Implement Java Programs for Events and interactivity using Layout Manager.	Apply
CO6	Create Java programs for network chatting and remote method development to construct an internet application.	Apply
CO7	Implement server side and client-side application using java servlet and java scripting language.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	S	M	S	-	L	-	-	-	-	-	-	-	M	L
CO2.	S	S	S	L	L	-	-	-	-	-	-	-	S	M
CO3	S	S	S	M	M	L	-	-	L	-	-	-	S	M
CO4	S	S	S	M	M	L	-	L	M	-	L	-	S	M
CO5	S	S	S	M	M	-	-	-	M	-	-	-	S	M
CO6	S	S	S	M	M	L	-	L	M	-	M	L	S	M
CO7	S	S	S	M	M	L	-	L	M	-	M	L	S	M

S- Strong; M-Medium; L-Low

List of Experiments

Develop Java Programs for

1. Use of Objects
2. Using classes and inheritance
3. JNI concepts
4. Multithread applications
5. Exception handling
6. Implementing packages and interfaces
7. Streams
8. Java Collection and utility Classes
9. JDBC Connectivity using different statements
10. Applet program for Animation text, images and sounds
11. Events and interactivity using AWT and Java swing.
12. Socket program for network chatting using Inter Process communication.
13. Client server application using RMI techniques
14. Java Servlets
15. Simple front-end design with validation script

Mini Project in Java

Reference Books:

1. Herbert Schildt, “Java: The Complete Reference-12th Edition”, McGraw Hill, 2021.
2. Paul Deitel and Harvey Deitel, “Java How to Program (Early Objects)”, Pearson, Eleventh Edition, 2017.

Course Designer(s):

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23DS510 NUMERICAL METHODS

Category	L	T	P	Credit
FC	4	0	0	4

Preamble

The students will be able to apply appropriate methods to solve algebraic, transcendental equations, polynomial equations, simultaneous linear equations and the inverse of a matrix. Also can calculate the solutions for problems related to interpolation, differentiation and integration and apply various methods for finding solutions of Ordinary and Partial Differential Equations.

Prerequisite

Nil

Course Outcomes

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

CO1	Solve the algebraic, transcendental and polynomial equations to find the numerical solutions	Apply
CO2	Solve the simultaneous linear equations to find the solutions and also to find inverse of the given matrix	Apply
CO3	Solve the given matrices by applying the concept of Power method and Jacobi method to find the Eigen values and Eigen vectors	Apply
CO4	Apply finite differences concepts and various interpolation methods for finding intermediate values of well-known data	Apply
CO5	Utilize various numerical methods in numerical differentiation and numerical integration related problems in real life statistical data and interpolate the value	Apply
CO6	Solve the ordinary differential equations and find the numerical solutions	Apply
CO7	Obtain the numerical solutions of partial differential equations	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	L	M	L	L	-	-	-	-	L	L	S	M
CO2	S	S	M	M	L	L	-	-	-	-	L	L	S	M
CO3	S	S	S	M	L	L	L	-	-	-	L	L	S	S
CO4	S	S	S	M	M	L	L	L	L	-	L	L	S	M
CO5	S	S	M	S	M	M	L	-	-	-	M	M	S	S
CO6	S	S	S	S	S	M	M	L	L	-	M	M	S	M
CO7	S	S	S	S	S	M	M	L	L	-	M	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	10	10						20																2	10				
CO2	2	5	20						20																2	10				
CO3	2		20						30																		14			
CO4	2	5	20						30																2		14			
CO5													4	10	20						30						14			
CO6													4	10	20						40				2		14			
CO7													2		30						30				2		14			
Total (in %)	100						100						100						100						100					

Syllabus

NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS: Types of error, Fixed point iteration method, Bisection method, Method of False position, Newton Raphson method, Bairstow's method.

NUMERICAL SOLUTION OF ALGEBRAIC SIMULTANEOUS EQUATIONS: Solution of linear system of equations: Gauss - elimination, Gauss - Jordan, Cholesky method, Crout"s method, Gauss – Jacobi method, Gauss – Seidel method, Matrix Inverse by Gauss – Jordan method.

EIGENVALUES AND EIGENVECTORS: Power method for finding dominant Eigen value and Eigen vectors, Inverse power method for finding smallest Eigen value, Jacobi method for symmetric matrices for finding dominant Eigen value and Eigen vectors.

INTERPOLATION AND CURVE FITTING: Finite difference operators - Interpolating Polynomials, Lagrange's interpolation, Divided Differences, Newton Forward and Backward Differences, Spline Curves methods.

NUMERICAL DIFFERENTIATION AND INTEGRATION: Numerical Differentiation - Newton forward, backward and divided differences. Numerical Integration - Trapezoidal rule, Simpson's (1/3)rd and (3/8)th rule, Double Integration - Trapezoidal rule and Simpson's (1/3)rd rule, Gaussian Quadrature.

NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS: Single step methods: Taylor's series method, Euler and Improved Euler methods, Fourth order Runge – Kutta method, Multistep methods: Milne's predictor - corrector method.

NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS: Classification of partial differential equations of second order. Solution of two dimensional Laplace's equations by Liebmann's iterative process and Poisson's equations, Solution of one dimensional heat equation using Bender Schmidt and Crank Nicholson difference schemes, Solution of one dimensional wave equation by explicit scheme.

Reference Books & web resources

1. Steven C. Chapra and Raymond P. Canale,"Numerical Methods for Engineers with Software and Programming Applications", 8th edition, published by McGraw Hill in 2020.
2. Timothy Sauer, Tim Sauer, "Numerical Analysis", 2nd Edition, Published by Pearson, 2014.
3. B.S. Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers, 42nd edition, 2017
4. Veerarajan, T., & Ramachandran, T., "Numerical methods with programs in C", Tata McGraw-Hill, 2014.
5. Sastry, S. S., "Engineering Mathematics" Vol. PHI Learning Pvt. Ltd., 2008.
6. https://www.math.hkust.edu.hk/~machas/numerical-methods.pdf
7.. https://www-users.cse.umn.edu/~arnold/8445.f11/notes.pdf
8. https://archive.nptel.ac.in/courses/111/107/111107063/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS**	
1.1	Types of error, Fixed point iteration method	2
1.2	Bisection method	1
1.3	Method of False position	1
1.4	Newton Raphson method	1
1.5	Bairstow's method	1
2	**NUMERICAL SOLUTION OF ALGEBRAIC SIMULTANEOUS EQUATIONS**	
2.1	Solution of linear system of equations: Gauss - elimination, Gauss - Jordan	2
2.2	Cholesky method, Crout"s method	2
2.3	Gauss – Jacobi method, Gauss – Seidel method	2
2.4	Matrix Inverse by Gauss – Jordan method	1
3	**EIGENVALUES AND EIGENVECTORS**	
3.1	Power method for finding dominant Eigen value and Eigen vectors, Inverse power method for finding smallest Eigen value	2
3.2	Jacobi method for symmetric matrices for finding dominant Eigen value and Eigen vectors	2
4	**INTERPOLATION AND CURVE FITTING**	
4.1	Finite difference operators, Interpolating Polynomials	1
4.2	Lagrange's interpolation	1
4.3	Divided Differences	1
4.4	Newton Forward and Backward Differences	2
4.5	Spline Curves methods	2
5	**NUMERICAL DIFFERENTIATION AND INTEGRATION:**	
5.1	Numerical Differentiation - Newton forward, backward and divided differences	3
5.2	Numerical Integration - Trapezoidal rule, Simpson's (1/3)rd and (3/8)th rule	2
5.3	Double Integration - Trapezoidal rule and Simpson's (1/3)rd rule	2
5.4	Gaussian Quadrature	2

Module No.	Topic	No. of Periods
6	**NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS**	
6.1	Single step methods: Taylor's series method	2
6.2	Euler and Improved Euler methods	2
6.3	Fourth order Runge – Kutta method	2
6.4	Multistep methods: Milne's predictor - corrector method	2
7	**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**	
7.1	Classification of partial differential equations of second order	1
7.2	Solution of two dimensional Laplace's equations by Liebmann's iterative process and Poisson's equations	3
7.3	Solution of one dimensional heat equation using Bender Schmidt and Crank Nicholson difference schemes	2
7.4	Solution of one dimensional wave equation by explicit scheme	1
	Total	**48**

Course Designer(s):

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23DS520 OPTIMIZATION TECHNIQUES

Category	L	T	P	Credit
FC	4	0	0	4

Preamble

This course will enable students to learn and apply optimization techniques to enhance Linear Programming Problem, Non-Linear Programming Problem, Integer Programming Problem and Dynamic Problems for solving complex real-world problems efficiently. Linear programming for resource allocation, NLPP allows to apply optimization techniques in Quadratic Programming Problem, Dynamic Programming to solve complex problems in Networks and Global optimization finds the absolute best solution.

Prerequisite

Nil

Course Outcomes

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

CO1	Apply linear programming techniques like Graphical, Simplex, Big M, and Two Phase & Dual Simplex Methods for optimum solutions.	Apply
CO2	Apply the transportation model for testing the closeness of their results to optimal results. Solve the assignment problem through Hungarian algorithm to domain specific situations.	Apply
CO3	Determine the optimum values of integer programming problems using Gomary‘s cutting plane method.	Apply
CO4	Apply the concepts of PERT and CPM for decision making and optimally managing projects.	Apply
CO5	Analyse and apply appropriate inventory techniques in domain specific situations.	Apply
CO6	Analyse and Apply the concept of Convex Optimization in Quadratic Programming.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	M	S	L	L	M	L	M	M	M	S	M
CO2	M	M	S	M	S	L	L	L	-	M	M	M	M	S
CO3	S	S	S	M	M	-	-	-	-	L	L	L	S	M
CO4	M	M	M	S	M	L	L	M	-	-	L	L	M	M
CO5	M	M	M	S	M	M	M	M	L	M	L	L	M	S
CO6	S	S	S	S	S	M	L	M	L	M	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	10	20					10	20																2		20			
CO2	4		30					20	20																2	5	10			
CO3	2	10	20					10	20																2	10				
CO4													4	10	20					10	20				2	5	10			
CO5													2		30					20	20						20			
CO6													4	10	20					10	20				2		10			
Total (in %)	100						100						100						100						100					

Syllabus

LINEAR PROGRAMMING PROBLEM: Modelling with linear programming model - Graphical solution for two dimensional problems - Simplex method, Big M- method - Two phase simplex methods. Dual Simplex Method - Special cases in the simplex method.

TRANSPORTATION & ASSIGNMENT MODEL: North West Corner Rule, Least Cost Method, and Vogel's Approximation Methods - Test for optimality - Real-Life Application - Hungarian algorithm Variants of the Assignment problem - Travelling Salesman Problem.

INTEGER LINEAR PROGRAMMING PROBLEM: Gomary's cutting plane method - Branch and Bound method.

NETWORK ANALYSIS: Introduction - Phases of Project Management IN Network Analysis - Critical path Method - Project Evaluation and Review Techniques.

INVENTORY MODEL - Inventory Problem: A Supply Chain Perspective - Static EOQ Models - Dynamic EOQ Models – Single & Multi Period Model**.**

NON-LINEAR PROGRAMMING PROBLEM: Convex sets - Convex functions - Convex optimization problems- Direct search Methods – Gradient Method - Quadratic Programming.

Reference Books & web resources

1. Hamdy A. Taha: "Operations Research – An Introduction" Prentice Hall of India Pvt Ltd., 10th Edition, 2019.
2. Sharma J.K.: "Operations Research Theory and applications", Macmillan India Ltd., V Edition, 2015.
3. Chandrasekara Rao, K. Shanti Lata Misra, "Operation Research", Alpha science international Ltd-2015.
4. Kanti Swarup, P.K.Gupta and Man Mohan, "Operations Research", Sultan Chand,20th Edition, 2022.
5. https://www.khanacademy.org/math/multivariable-calculus/applications-of-multivariable-derivatives/constrained-optimization/a/lagrange-multipliers-examples
6. https://archive.nptel.ac.in/courses/111/102/111102012/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**LINEAR PROGRAMMING**	
1.1	Modelling with linear programming model	1
1.2	Graphical solution for two dimensional problems	1
1.3	Simplex method, Big M- method	1
1.4	Two phase simplex methods	2
1.5	Dual Simplex Method	2
1.6	Special cases in the simplex method	1
2	**TRANSPORTATION & ASSIGNMENT MODEL**	

Module No.	Topic	No. of Periods
2.1	Introduction, Mathematical Model of Transportation Problem	1
2.2	Methods for Finding Initial Solution using NWCR & LCM	2
2.3	Method for Finding Initial Solution using VAM	1
2.4	Test for Optimality	1
2.5	Mathematical Models of Assignment Problem	1
2.6	Hungarian Method for Solving Assignment Problem	1
2.7	Variations of the Assignment Problem	1
3	**INTEGER LINEAR PROGRAMMING**	
3.1	Introduction - Types of Integer Programming Problems	1
3.2	Gomary‘s cutting plane method	2
3.3	Gomory’s Mixed-Integer Cutting Plane Method	2
3.4	Branch and Bound Method	2
4	**NETWORK ANALYSIS**	
4.1	Introduction, Basic Differences Between PERT and CPM	2
4.2	Phases of Project Management	2
4.3	Critical Path Analysis	2
4.4	Project Evaluation and Review Techniques	2
5	**INVENTORY CONTROL**	
5.1	Inventory Model - A Supply Chain Perspective	1
5.2	Static EOQ Models	2
5.3	Dynamic EOQ Models	2
5.4	Single & Multi Period Model	2
6	**NON-LINEAR PROGRAMMING**	
6.1	Convex sets	1
6.2	Convex functions	2
6.3	Convex optimization problems	1
6.4	Direct search Methods	1
6.5	Gradient Method	1

Module No.	Topic	No. of Periods
6.6	Quadratic Programming Problem	2
	Total	**46**

Course Designer:

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23DS530 **WEB TECHNOLOGY**

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

This syllabus on Web Technology introduces essential concepts and practices in web development, covering both client-side and server-side programming. It emphasizes key technologies such as HTML, CSS, JavaScript, PHP, JSP, and database access. Students will develop practical skills to create dynamic and interactive web applications.

Prerequisite

Nil

Course Outcomes

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

CO1	Understand the fundamental concepts of web technology, including the structure and function of web applications.	Understand
CO2	Create web pages using HTML, CSS, and JavaScript for interactive user experiences.	Apply
CO3	Develop server-side applications using PHP and handle web form data efficiently.	Apply
CO4	Use XML and related technologies for data interchange and presentation in web applications.	Apply
CO5	Deploy and manage web applications using web servers and servlets, ensuring proper session handling and data management.	Apply
CO6	Implement databases connectivity using JDBC and PHP for a web applications	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	S	S	-	-	M	-	-	-	-	-	S	S
CO2	S	S	M	S	L	-	M	-	S	-	-	-	S	S
CO3	M	M	S	M	-	-	-	-	-	-	M	-	S	M
CO4	S	S	S	S	M	-	-	-	-	M	-	-	S	M
CO5	L	S	M	M	S	S	-	-	M	-	S	-	S	S
CO6	S	S	S	S	M	L	-	M	M	-	-	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2					Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10						20																	10	10				
CO2	10	10	20						40																	10	10			
CO3		10	30						40																		20			
CO4													10	10	10					10	10						10			
CO5													10	10	30					40						10	10			
CO6															20						40						10			
Total (in %)	100						100						100						100					100						

Syllabus

WEB BASICS AND HTML: **Introduction to Internet:** World Wide Web, Web Browsers, URL, MIME, HTTP, Web Programmer's Tool Box – **HTML Common Tags:** Lists, Tables, Images, Forms, Frames.

CSS AND CLIENT-SIDE PROGRAMMING: Basics of CSS: Types of CSS - **Client-Side Programming (JavaScript):** Introduction to JavaScript, Declaring Variables, Functions, Event Handlers (onclick, onsubmit, etc.), Form Validation.

SERVER-SIDE PROGRAMMING WITH PHP: PHP Basics: Declaring Variables, Data Types, Operators, Control Structures, Functions - **Web Form Data Handling:** Reading data from web form controls like text, buttons, radio buttons, lists, etc.

ADVANCED PHP AND XML: Advanced PHP: Handling File Uploads, Sessions, and Cookies - **Introduction to XML:** Document Type Definition (DTD), XML Schemas, Document Object Model (DOM), Presenting XML.

WEB SERVERS, SERVLETS, AND JSP: Web Servers: Tomcat Web Server, Installing the Java Software Development Kit, Tomcat Server & Testing Tomcat - **Introduction to Servlets:** Servlet Lifecycle, JSDK, Deploying Servlet, The Servlet API, The javax.servlet Package - **JSP Overview:** The Problem with Servlets, Anatomy of a JSP Page, JSP Processing.

DATABASE ACCESS AND JAVABEANS: Database Programming using JDBC: JDBC Drivers, Studying Javax.sql. * Package, Accessing a Database from a Servlet and JSP Page - **PHP Database Connectivity:** Connecting to a Database in PHP, Executing Simple Queries - **JavaBeans:** Introduction to JavaBeans, Deploying JavaBeans in a JSP Page.

Reference Books

1. Uttam K. Roy, "Web Technologies", Oxford University Press, 1st Edition (2010).
2. Steven Holzner, "PHP: The Complete Reference", McGraw-Hill, 1st Edition (2008).
3. Chris Bates, "Web Programming: Building Internet Applications", 3rd Edition, Wiley (2010).
4. Hans Bergsten, "Java Server Pages", O'Reilly, 3rd Edition (2003).
5. Jon Duckett, "Beginning Web Programming", WROX, 2nd Edition (2012).
6. R.W. Sebesta, "Programming the World Wide Web", 8th Edition, Pearson (2015).
7. Deitel & Deitel, "Internet and World Wide Web: How to Program", 6th Edition, Pearson (2011).
8. Paul S. Wang, "An Introduction to Web Design and Programming", 1st Edition, Cengage Learning (2003).
9. Marty Hall & Larry Brown, "Core Servlets and JavaServer Pages: Core Technologies", Volume 1, 2nd Edition, Pearson (2003).

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**WEB BASICS AND HTML**	
1.1	Introduction to Internet: World Wide Web, Web Browsers, URL, MIME, HTTP, Web Programmer's Tool Box.	4

1.2	HTML Common Tags: Lists, Tables, Images, Forms, Frames.	4
2	**CSS AND CLIENT-SIDE PROGRAMMING**	
2.1	Basics of CSS: Types of CSS.	3
2.2	Client-Side Programming (JavaScript): Introduction to JavaScript, Declaring Variables, Functions, Event Handlers (onclick, onsubmit, etc.), Form Validation.	5
3	**SERVER-SIDE PROGRAMMING WITH PHP**	
3.1	PHP Basics: Declaring Variables, Data Types, Operators, Control Structures, Functions.	5
3.2	Web Form Data Handling: Reading data from web form controls like text, buttons, radio buttons, lists, etc.	4
4	**ADVANCED PHP AND XML**	
4.1	Advanced PHP: Handling File Uploads, Sessions, and Cookies	5
4.2	Introduction to XML: Document Type Definition (DTD), XML Schemas, Document Object Model (DOM), Presenting XML.	4
5	**WEB SERVERS, SERVLETS, AND JSP**	
5.1	Web Servers: Tomcat Web Server, Installing the Java Software Development Kit, Tomcat Server & Testing Tomcat.	3
5.2	Introduction to Servlets: Servlet Lifecycle, JSDK, Deploying Servlet, The Servlet API, The javax.servlet Package.	4
5.3	JSP Overview: The Problem with Servlets, Anatomy of a JSP Page, JSP Processing.	4
6	**DATABASE ACCESS AND JAVABEANS**	
6.1	Database Programming using JDBC: JDBC Drivers, Studying Javax.sql.* Package, Accessing a Database from a Servlet and JSP Page.	4
6.2	PHP Database Connectivity: Connecting to a Database in PHP, Executing Simple Queries.	3
6.3	JavaBeans: Introduction to JavaBeans, Deploying JavaBeans in a JSP Page.	3
	Total	**44**

Course Designer:

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23DS540 MACHINE LEARNING

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

The course aims to provide an theoretical foundations and hands-on applications of Machine Learning and impart advanced knowledge on the foundational principles of Predictive Analytics

Prerequisite

- 23DS220- Applied Statistics
- 23DS420 – Predictive Analytics

Course Outcomes

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

CO1	Apply various parametric methods like Maximum Likelihood Estimation and Bayes' Estimator for classification and regression tasks with a knowledge of Bayesian decision theory	Apply
CO2	Identify methods to handle multivariate data on performing classification and regression using multivariate techniques including parametric methods	Analyze
CO3	Apply dimensionality reduction techniques of subset selection, PCA and LDA to simplify high-dimensional data problems	Apply
CO4	Apply non-parametric methods to perform classification, regression, and clustering on multivariate data	Apply
CO5	Implement gradient descent and logistic discrimination algorithms for classification problems.	Apply
CO6	Construct kernel methods for implementing maximum margin classifiers	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	M	L	L	L	L	L	-	L	S	S
CO2	S	S	M	M	M	L	L	L	L	L	-	L	S	S
CO3	S	M	M	M	M	L	L	L	L	L	-	L	S	S
CO4	S	M	M	M	M	L	L	L	L	L	-	L	S	S
CO5	S	M	M	M	M	L	L	L	L	L	-	L	S	S
CO6	S	M	M	M	M	L	L	L	L	L	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10	20						50																4		15			
CO2	5			20						25			5		10						25				4			15		
CO3	5	10	20						25																2	5	10			
CO4													5	5	20						25				2	5	10			
CO5													5	5	20						25				4		10			
CO6													5	10	10						25				4	10				
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION: Introduction to Machine Learning – Basic concepts, Model selection – Supervised, Unsupervised, Reinforcement Learning- Example applications **–** Bayesian Decision Theory

PARAMETRIC METHODS: Introduction, Maximum Likelihood estimation, Evaluating an estimator, Bayes' estimator, Bayes estimation of regression and classification of parameters, Parametric classification, Regression, Tuning model complexity, Model selection procedures - Demonstrations

MULTIVARIATE METHODS: Multivariate data, Parameter estimation, Estimation of missing values, Multivariate normal distribution, Multivariate classification, Tuning complexity, Discrete features, Multivariate regression - Demonstrations

DIMENSIONALITY REDUCTION: Introduction, Subset Selection, Principal Components Analysis, Multidimensional Scaling, Linear Discriminant Analysis – Demonstrations

CLUSTERING: k- Means Clustering, Expectation Maximization

NON-PARAMETRIC METHODS: Introduction, Non-parametric density estimation, Generalization to multivariate data, Non-parametric classification, Non-parametric regression - Demonstrations

LINEAR DISCRIMINATION: Generalizing linear model, Linear discriminant, Pairwise separation, Gradient descent, Logistic discrimination, Discrimination by regression - Demonstrations

KERNEL METHODS : Dual Representations, Constructing Kernels, Radial Basis Function networks, Gaussian processes for Regression and classification – Laplace approximation, Maximum margin classifiers (SVM for classification and regression)

Reference Books & web resources

1. Ethem Alaypadin, "Introduction to Machine Learning", Fourth Edition, MIT Press, 2020 (Chapters 1,2,3,4,5,6,7,8,10)
2. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2013 (Chapters 6,7)
3. Kevin P. Murphy, "Machine Learning: A probabilistic perspective", MIT Press, 2012.
4. Trevor Hastie, Robert, Jerome, "The elements of statistical learning: Datamining, Inference and Prediction", 2nd Edition, 2009.
5. Aurelien Geron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" , O'Reilly Media, 2022

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO MACHINE LEARNING**	
1.1	Basic concepts, types of learning	1

Module No.	Topic	No. of Periods
1.2	Model Selection- Supervised	1
1.3	Unsupervised and reinforcement learning	1
1.4	Applications of Machine Learning	1
1.5	Bayesian Decision Theory	2
2	**PARAMETRIC METHODS**	
2.1	Introduction, Maximum Likelihood estimation	1
2.2	Evaluating an estimator, Bayes' estimator	2
2.3	Parametric classification, Regression	2
2.4	Tuning model complexity	1
2.5	Model selection procedures	1
2.6	Demonstrations	1
3	**MULTIVARIATE METHODS**	
3.1	Multivariate data, Parameter estimation	1
3.2	Estimation of missing values, Multivariate normal distribution	1
3.3	Multivariate classification, Tuning complexity	1
3.4	Discrete features, Multivariate regression	2
3.5	Demonstrations	1
4	**DIMENSIONALITY REDUCTION**	
4.1	Introduction, Subset Selection	1
4.2	Principal Components Analysis	1
4.3	Multidimensional Scaling	1
4.4	Linear Discriminant Analysis	1
4.5	Demonstrations	1
5	**CLUSTERING**	
5.1	k- Means Clustering	2
5.2	Expectation Maximization	1
5.3	Demonstrations	1
6	**NON-PARAMETRIC METHODS**	

Module No.	Topic	No. of Periods
6.1	Introduction, Non-parametric density estimation	2
6.2	Generalization to multivariate data	1
6.3	Non-parametric classification, Non-parametric regression	1
6.4	Demonstrations	1
7	**LINEAR DISCRIMINATION**	
	Generalizing linear model, Geometry of linear discriminant	1
7.1	Pairwise separation, Gradient descent	1
7.2	Logistic discrimination	1
7.3	Discrimination by regression	1
7.4	Demonstration	1
8	**KERNEL METHODS**	
8.1	Dual Representations, Constructing Kernels	1
8.2	Radial Basis Function networks	1
8.3	Maximum margin classifiers (SVM for classification and regression)	2
8.4	Gausian processes	2
8.5	Laplace approximation	1
	Total	**46**

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23DS550 COMPUTER NETWORKS

Category	L	T	P	Credit
PCC	4	0	0	4

Preamble

The course aims to provide an understanding of computer networks architecture, various technologies available to build a network and protocols in use at different levels of network layers stack. An overview of global Internet, Internet applications and introduction to Network simulation is also provided.

Prerequisite

Nil

Course Outcomes

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

CO1	Apply the fundamentals of networking, including physical transmission media and LAN/WAN technologies (Ethernet, IEEE 802.11), to establish network connectivity.	Apply
CO2	Apply data link layer protocols, including CSMA/CD, flow, and error control techniques, for reliable data transfer.	Apply
CO3	Analyze IP addressing, subnetting, and routing protocols (RIP, OSPF) to enable efficient internetworking, and evaluate network performance metrics like latency and throughput.	Analyze
CO4	Examine transport layer protocols (TCP/UDP) with emphasis on connection management, flow, and congestion control.	Analyze
CO5	Utilize application layer protocols (HTTP, FTP, DNS) for providing essential end-user network services.	Apply
CO6	Use cryptographic techniques to secure data communication and ensure network integrity.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	L	S	L	L	L	L	L	L	L	L	L
CO2	S	S	M	L	S	L	L	L	L	L	L	L	L	L
CO3	S	S	S	M	M	L	L	L	L	M	L	L	L	M
CO4	S	S	S	M	M	L	L	L	L	M	L	L	L	M
CO5	S	S	M	L	S	L	L	L	L	L	L	L	L	M
CO6	S	S	M	L	S	L	L	L	S	L	L	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	10	10						20																4	5	10			
CO2	10	10	10						30																4	5	10			
CO3		20	10	10					30	20															4	5		10		
CO4													5	10	10	10					30	20			4	5		10		
CO5													5	10	20						30				2		10			
CO6													10	10	10						20				2		10			
Total (in %)	100						100						100						100						100					

Syllabus

NETWORK ARCHITECTURE AND COMPONENTS – ISO/OSI architecture – Functionalities of OSI Layers - TCP/IP architecture – Types of Networks (LAN, WAN, VPN, VLAN) – Network Components (NIC, Bridges, Switches, Routers, Hubs, Gateways)

NETWORK TECHNOLOGIES TO CONNECT HOSTS – LAN Technologies (Ethernet, Token Ring) WAN Technologies (Circuit switching- ISDN , Packet Switching – Frame Relay - (IEEE802.11) – Multiple Access – CSMA/CD – Flow control techniques – Error control techniques.

INTERNETWORKING – IPv4 – Global Addresses – ARP – DHCP – ICMP – Routing – Intra domain Routing algorithms (RIP, OSPF) – Subnetting – Classless Addressing – Inter domain routing – Ipv6 – Multicasting – VoIP.

PROTOCOL STACK – End to End protocols [TCP (segment format, connection establishment & Termination, Congestion control, Flow Control), UDP] - Application layer protocols (SMTP, IMAP, POP, HTTP, FTP, DNS, Telnet).

NETWORK PERFORMANCE AND SIMULATION – Bandwidth – latency – Throughput - Jitter – Delay

NETWORK SECURITY – Security goals, Attacks, Services and Techniques. Confidentiality-Symmetric-Key Ciphers, Asymmetric-Key Ciphers. Message Integrity, Message Authentication, Digital Signature, Entity Authentication, Key Management.

Reference Books & web resources

1. Behrouz A. Foruzan, ” Data Communication and Networking”, Tata McGraw Hill, Sixth Edition, 2022. (Chapters 1 -3, 9-13, 15, 17,18, 20, 21, 22, 24-26,31)
2. William Stallings, ” Data and Computer Communications”, Pearson Education Ninth Edition 2013.
3. Larry L. Peterson and Bruce S. Davie, ” Computer Networks – A systems Approach” Fifth Edition, Morgan Kaufmann Publishers,2011

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**NETWORK ARCHITECTURE AND COMPONENTS**	
1.1	ISO/OSI architecture	1
1.2	Functionalities of OSI Layers	2
1.3	TCP/IP architecture	1
1.4	Types of Networks (LAN, WAN,	2
1.5	VPN, VLAN)	2
2	**NETWORK TECHNOLOGIES TO CONNECT HOSTS**	
2.1	LAN Technologies (Ethernet, Token Ring)	1
2.2	WAN Technologies	1

Module No.	Topic	No. of Periods
2.3	Circuit switching- ISDN	2
2.4	Packet Switching – Frame Relay	2
2.5	(IEEE802.11) – Multiple Access – CSMA/CD	1
2.6	Flow control techniques	2
2.7	Error control techniques.	2
3	**INTERNETWORKING**	
3.1	IPv4 – Global Addresses	1
3.2	ARP – DHCP – ICMP- Routing	2
3.3	Intra domain Routing algorithms (RIP, OSPF)	2
3.4	Subnetting – Classless Addressing – Inter domain routing	2
3.5	Ipv6 – Multicasting	1
3.6	VoIP.	1
4	**PROTOCOL STACK**	
4.1	End to End protocols	1
4.2	TCP (segment format, connection establishment & Termination, Congestion control, Flow Control),	2
4.3	UDP .	1
4.4	Application layer protocols	1
4.5	SMTP, IMAP	2
4.6	POP, HTTP	2
4.7	FTP, DNS, Telnet	2
5	**NETWORK PERFORMANCE AND SIMULATION**	
5.1	Bandwidth – latency – Throughput	1
5.2	Jitter – Delay	1
6	**NETWORK SECURITY**	
6.1	Security goals, Attacks, Services and Techniques	1
6.2	Confidentiality- Symmetric-Key Ciphers, Asymmetric-Key Ciphers	1
6.2	Message Integrity, Message Authentication, Digital Signature, Entity Authentication, Key Management	2
	Total	**45**

Course Designer:

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23DS570	WEB TECHNOLOGY LAB	Category	L	T	P	Credit
		PCC	0	0	4	4

Preamble

This lab course aims to provide hands-on experience in building and deploying dynamic web applications, enabling students to design and implement interactive websites using modern web technologies. Students will learn client-server architecture, web development frameworks, and database connectivity essential for data-driven applications in the field of Data Science.

Prerequisite

- 23DS280 - Object Oriented Programming Lab
- 23DS480 – Java Programming Lab

Course Outcomes

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

CO1	Apply modern web technologies to design and implement responsive static web pages using HTML5, CSS3, and JavaScript.	Apply
CO2	Apply client-side scripting techniques to create dynamic and interactive user interfaces with JavaScript and its frameworks.	Apply
CO3	Apply server-side programming to develop and deploy web applications using JSP and PHP	Apply
CO4	Apply asynchronous JavaScript, Servlets techniques to build real-time web applications with smooth user experiences.	Apply
CO5	Create a full-stack web application integrating front-end and back-end technologies with a database to manage user data and interactions.	Create
CO6	Create an interactive data dashboard or web application by integrating data visualization tools and machine learning models to display real-time analytics and predictions.	Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO2	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO3	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO4	S	M	M	M	S	L	L	L	M	L	-	M	S	S
CO5	S	S	S	S	S	S	S	S	S	S	S	S	S	S
CO6	-	-	-	-	L	L	L	M	S	L	-	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

- **Introduction to HTML5 and CSS3:** Designing static web pages with responsive design using CSS frameworks.
- **Client-Side Scripting with JavaScript:** Implement form validation, interactive web components using JavaScript DOM manipulation.
- **Introduction to JavaScript Libraries and Frameworks:** Using jQuery and other libraries for creating dynamic content and React requests.
- **Servlets -** Handling HTTP Requests and Responses - Form Data Handling in Servlets - Session Management in Servlets

- **JSP -** JSP scriptlets, expressions, and directives - JSP Implicit Objects - Error Handling in Servlets and JSP - Database Connectivity with JSP
- **PHP:** Setting up a local server environment (XAMPP, WAMP, or LAMP) - HTML forms and form handling in PHP – PHP with MySQL.
- Integrating PHP and JSP/Servlets with React.

Reference Books & web resources

1. Robin Nixon, “Learning PHP, MySQL, JavaScript, CSS & HTML5”, O'Reilly Media, 2018.
2. David Flanagan, “JavaScript: The Definitive Guide”, O'Reilly Media, 2020.
3. Ethan Brown, “Web Development with Node and Express”, O'Reilly Media, 2019.
4. Eric Freeman, Elisabeth Robson, “Head First HTML and CSS”, O'Reilly Media, 2012.
5. Brad Dayley, “Node.js, MongoDB, and Angular Web Development”, Addison-Wesley, 2017.
6. Mozilla Developer Network (MDN) Web Docs – Comprehensive documentation for web technologies (HTML, CSS, JavaScript).
7. W3Schools – A popular platform for web development tutorials.
8. Stack Overflow – Community-driven Q&A for troubleshooting code.
9. React Documentation – Official guide to learning React.
10. Node.js Documentation – Official Node.js API documentation.

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		Category	L	T	P	Credit
23DS580	**MINI PROJECT**	EEC	0	0	6	3

Preamble

The primary objective of this mini project is to enhance practical skills in data manipulation, statistical analysis, and machine learning while developing a deeper understanding of relevant concepts or theories.

Prerequisite

- Nil

Course Outcomes

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

CO1	Identify and describe the real time problem statement	Analyze
CO2	Create the architecture and various design diagrams such as ER Diagram, DFD, Use case diagram, User Interface Design.	Analyze
CO3	Apply algorithms or methodologies to real-world problems in the project.	Apply
CO4	Design a prototype or model based on findings.	Create
CO5	Develop a comprehensive report or presentation that integrates all project aspects.	Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	S	-	S	S	-	M	L	M	S	M	L	M	S
CO2	S	S	S	L	S	S	L	L	S	S	L	L	S	S
CO3	M	S	S	S	S	M	M	S	S	S	S	S	S	S
CO4	M	S	S	M	S	M	M	S	S	S	S	L	S	S
CO5	M	S	M	M	M	M	M	S	S	S	M	M	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Review-I	Review-II	Review-III	Terminal
Bloom's level				
CO1	10	10	10	10
CO2	10	10	10	10
CO3	20	20	20	20
CO4	20	20	20	20
CO5	20	20	20	20
CO6	20	20	20	20
Total (in %)	100	100	100	100

Syllabus

INTRODUCTION MODULE - Title, Abstract, Introduction, Problem Statement in local business sectors, Objectives,

LITERATURE REVIEW MODULE - Existing System, Proposed System, Modules Split-up and Gantt Chart, Gaps in Current system

Design and Architecture Module - Architecture Diagram, ER Diagram, DFD, Use case diagram (if necessary), User Interface Design

IMPLEMENTATION MODULE - Development Environment Setup, Coding-Key Algorithms/Functions (100% of code implementation)

TESTING MODULE - Testing Strategies (Unit, Integration, System), Test Cases and Results,

RESULTS MODULE - Data Analysis, Performance Metrics, Visualization of Results (Charts/Graphs)

DISCUSSION MODULE - Interpretation of Results, Comparison with Expected Outcomes, Limitations of the Study

CONCLUSION MODULE - Summary of Findings, Implications of the Work, Suggestions for Future Work

DOCUMENTATION MODULE - User Manual, Technical Documentation, Code Comments and Explanation with screenshots

REFERENCES MODULE - Citations

Reference Books & web resources

1. Gregory M.Horine, "Project Management Absolute Beginner's Guide", QUE, 5th Edition, 2022
2. GitHub: github.com
3. Kaggle: kaggle.com.

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23DS610	DEEP LEARNING	Category	L	T	P	Credit
		PCC	4	0	0	4

Preamble

This course aims to provide a comprehensive understanding of deep learning concepts and architectures, including CNNs, RNNs, and generative models. It emphasizes key techniques in optimization, regularization, and hyper parameter tuning for effective model evaluation. Students will explore practical applications of deep learning across various domains.

Prerequisite

- 23DS540- Machine Learning.

Course Outcomes

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

CO1	Identify the foundational concepts of deep learning, including neural networks, activation functions, and loss functions.	Apply
CO2	Design convolutional neural networks (CNNs), including their architectures and applications.	Apply
CO3	Apply regularization techniques and optimization methods to improve model performance, incorporating strategies such as data augmentation for enhanced results.	Apply
CO4	Utilize hyper parameter tuning and model evaluation methods, emphasizing the role of optimization techniques in refining deep learning models for better accuracy and efficiency.	Apply
CO5	Design recurrent neural networks (RNNs) and their variants for effective sequence modeling.	Apply
CO6	Construct generative models and transformers for data generation and attention mechanisms.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	S	M	-	L	L	-	L	-	S	S
CO2	S	S	S	M	S	M	L	L	L	L	L	L	S	S
CO3	S	S	S	L	S	-	-	-	-	-	-	-	S	M
CO4	S	S	S	L	S	-	-	-	-	-	-	-	S	M
CO5	S	S	S	M	S	M	L	L	L	L	L	L	S	S
CO6	S	S	S	M	S	M	L	L	L	-	L	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10	20						25																2	5	15			
CO2	5	10	25						50																2	5	15			
CO3	5	10	10						25																2		10			
CO4													5	10	15						25				2		10			
CO5													5	10	20						50				2	5	10			
CO6													5	10	20						25					5	10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO DEEP LEARNING: Overview of Deep Learning: Motivation and Applications **-** Neural Networks and Biological Neurons **-** Deep Feedforward Networks **-** Backpropagation of Neural Networks **-** Activation Functions: ReLU, Leaky ReLU, Swish, etc. **-** Loss and Cost Functions**.**

CONVOLUTIONAL NEURAL NETWORKS (CNNS): Convolution and Pooling Operations **-** Backpropagation in CNNs **-** CNN Architectures: LeNet, AlexNet, VGG, ResNet, EfficientNet **-** Transfer Learning and Fine-Tuning Pretrained Networks**.**

REGULARIZATION AND GENERALIZATION IN DEEP LEARNING: Overfitting and Underfitting: Concepts and Impacts **-** Dropout **-** Batch Normalization and Layer Normalization **-** L1 and L2 Regularization Techniques **-** Data Augmentation Strategies: Geometric Transformations, Color Space Augmentation, Random Erasing and Noise injection.

OPTIMIZATION TECHNIQUES FOR DEEP LEARNING: Gradient Descent: Theory and Applications **-** Variants (SGD, Momentum, RMSprop, Adam, AdamW) **-** Advanced Optimization Techniques: Gradient Clipping**,** Learning Rate Scheduling**,** Gradient Accumulation, Early Stopping**.**

HYPER PARAMETER TUNING AND EVALUATION METHODS: Hyper parameter Tuning (Grid Search**,** Random Search**,** Bayesian Optimization) **-** Model Evaluation Methods: Train/Test Split, Cross-Validation - Evaluation Metrics: Accuracy**,** MAE, MSE, Confusion Matrix**,** Precision-Recall, F1-Score, ROC-AUC**.**

SEQUENCE MODELING AND TEMPORAL DATA: Recurrent Neural Networks (RNNs): Architecture and Use Cases **-** Backpropagation in RNNs **-** Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU) **-** Backpropagation Through Time (BPTT) for LSTMs**-** Introduction to Bidirectional RNNs.

GENERATIVE MODELS AND TRANSFORMERS: Generative Adversarial Networks (GANs) and Variants: WGAN, CycleGAN **-** Variational Autoencoders(VAEs) **-** Applications of Generative Models in Data Augmentation and Image Generation **-** Introduction to Attention Mechanisms and Transformers**:** Vision Transformers (ViT) and Efficient Vision Models.

Reference Books

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning” (Adaptive Computation and Machine Learning Series), MIT Press, 2016.
2. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow”, O'Reilly Media, 2019.
3. François Chollet, “Deep Learning with Python”, Manning Publications, 2021.
4. Charu Aggarwal, “Neural Networks and Deep Learning: A Textbook”, Springer, 2023.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO DEEP LEARNING**	
1.1	Overview of Deep Learning: Motivation and Applications	1
1.2	Neural Networks and Biological Neurons	1
1.3	Deep Feedforward Networks	1

Module No.	Topic	No. of Periods
1.4	Backpropagation of Neural Networks	2
1.5	Activation Functions (ReLU, Leaky ReLU, Swish, etc.)	1
1.6	Loss and Cost Functions	1
2	**CONVOLUTIONAL NEURAL NETWORKS (CNNS)**	
2.1	Convolution and Pooling Operations	1
2.2	Backpropagation in CNNs	2
2.3	CNN Architectures: LeNet, AlexNet, VGG, ResNet, EfficientNet	2
2.4	Transfer Learning and Fine-Tuning Pretrained Networks	2
3	**REGULARIZATION AND GENERALIZATION IN DEEP LEARNING**	
3.1	Overfitting and Underfitting: Concepts and Impacts	1
3.2	Dropout	1
3.3	Batch Normalization and Layer Normalization	1
3.4	L1 and L2 Regularization Techniques	1
3.5	Data Augmentation Strategies- Geometric Transformations, Color Space Augmentation, Random Erasing and Noise injection.	2
4	**OPTIMIZATION TECHNIQUES FOR DEEP LEARNING**	
4.1	Gradient Descent: Theory and Applications	1
4.2	Variants (SGD, Momentum, RMSprop, Adam, AdamW)	2
4.3	Advanced Optimization Techniques: Gradient Clipping, Learning Rate Scheduling, Gradient Accumulation, Early Stopping.	2
5	**HYPER PARAMETER TUNING AND EVALUATION METHODS**	
5.1	Hyper parameter Tuning (Grid Search, Random Search, Bayesian Optimization)	2
5.2	Model Evaluation Methods: Train/Test Split, Cross-Validation.	1
5.3	Evaluation Metrics: Accuracy, MAE, MSE, Confusion Matrix, Precision-Recall, F1-Score, ROC-AUC.	2
6	**SEQUENCE MODELING AND TEMPORAL DATA**	
6.1	Recurrent Neural Networks (RNNs): Architecture and Use Cases	1
6.2	Backpropagation in RNNs	1
6.3	Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU)	2
6.4	Backpropagation Through Time (BPTT) for LSTMs	1
6.5	Introduction to Bidirectional RNNs.	1

Module No.	Topic	No. of Periods
7	**Generative Models and Transformers**	
7.1	Generative Adversarial Networks (GANs) and Variants (WGAN, CycleGAN)	2
7.2	Variational Autoencoders (VAEs)	1
7.3	Applications of Generative Models in Data Augmentation and Image Generation	2
7.4	Introduction to Attention Mechanisms and Transformers**:** Vision Transformers (ViT) and Efficient Vision Models.	3
	Total	**44**

Course Designer

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23DS620	DATA MINING	Category	L	T	P	Credit
		PCC	4	0	0	4

Preamble

This course provides a comprehensive introduction to data mining, focusing on data pre-processing, similarity measures, classification, clustering, stream mining, and sequence pattern discovery to equip students with practical data analysis and predictive modelling skills.

Prerequisite

- 23DS220: Applied Statistics
- 23DS340: Database Systems

Course Outcomes

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

CO1	Explain the architecture of data mining process, issues and importance	Understand
CO2	Describe the types of data attributes and apply basic statistical measures to analyze data distribution and variability.	Apply
CO3	Apply suitable data pre-processing methods for the given dataset.	Apply
CO4	Apply proximity measures, to assess data similarity and dissimilarity, and implement association rule mining techniques	Apply
CO5	Apply decision tree algorithms, ensemble techniques, and clustering methods to perform classification, prediction, and data segmentation in various contexts.	Apply
CO6	Apply stream mining techniques and algorithms, and implement sequence mining methods to discover patterns and analyze multivariate time series data	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	M	-	-	-	L	L	L	L	M	M
CO2	S	S	L	M	M	-	-	-	L	L	L	L	M	S
CO3	M	M	M	M	S	-	-	-	M	L	M	L	M	S
CO4	M	S	M	M	S	-	-	-	M	L	M	L	M	S
CO5	M	S	S	M	S	-	-	-	M	L	M	L	S	S
CO6	M	S	S	M	S	-	-	-	M	L	M	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's Level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	10						20																	4	6				
CO2	10	10	20						40																4	6	10			
CO3	10	10	20						40																	6	10			
CO4													10		10						30				4		10			
CO5													10	10	20						40				4	6	10			
CO6													10	10	20						30				4	6	10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION: Motivation for Data Mining - Data Mining Issues -Importance - Data Mining from a Database Perspective -Classification of Data Mining Systems – Major issues in Data Mining.**Data Pre-Processing**:Types of data - Data cleaning – Aggregation - Sampling – Feature subset selection–wrapper and filter methods.

DATA OBJECTS AND ATTRIBUTE TYPES:Attribute, Nominal Attributes,Binary Attributes, Ordinal Attributes,Numeric Attributes,Discrete versus Continuous Attribute, Introduction to Basic Statistical Descriptions of Data.

Measuring Data Similarity and DISSIMILARITY: Data Matrix versus Dissimilarity Matrix, Proximity Measures for Nominal Attributes, Binary Attributes,Ordinal AttributesDissimilarity of Numeric Data, Minkowski Distance, Dissimilarity for Attributes of Mixed Types, Cosine Similarity. **Association Rules**: Large Itemsets, Market Basket Analysis,Apriori Algorithm, Sampling Algorithm, Partitioning, Pattern Mining: Constraint-based pattern mining,Mining sequential patterns.

DECISION TREE-BASED ALGORITHMS: ID3, C 4.5 and C5.0, CART, **Ensemble of classifiers:** Classification – Prediction – Voting, Bagging, Boosting, Stacking, Cascading, Random forest, introduction to Semi Supervised learning.

CLUSTERING:Hierarchical Algorithms-Agglomerative Algorithms, Divisive Clustering. **PartitionalAlgorithms**: Minimum Spanning Tree, K -Means Clustering, K-Mediods, Nearest Neighbor Algorithm, PAM Algorithm. **Clustering Large Databases**: BIRCH, DBSCAN, CURE Algorithm.

MINING DATA STREAMS: Challenges–Stream data model – Sampling data in a stream, Filtering streams: The Bloom Filter- Counting frequency items in a stream-The Count-Distinct Problem, TheFlajolet-Martin Algorithm.

SEQUENCE MINING: Characteristics of Sequence Data, Problem Modelling, Sequential Pattern Discovery, Timing Constraints, Multivariate Time Series (MVTS) Mining: Importance of MVTS data - Sources of MVTS data - Mining MVTS data.

CASE STUDIES: Web Mining, Spatial Mining, Graph Mining, Temporal Mining.

Reference Books& Web Resources

1. Jiwai Han and Micheline Kamber- “Data Mining – Concepts and Techniques”, Morgan Kaufmann,4th edition, 2022.
2. Tan, Steinbach, Kumar,- “Introduction to Data Mining”, Pearson Education, 2014.
3. AnandRajaraman and Jeffrey Ullman – “Mining Massive Data sets”, Cambridge University Press, 2014.
4. Giovanni Seni, John Elder – “Ensemble methods in data mining: Improving accuracy through combining prediction”, Morgan &ClayPool, 2010.
5. Trevor Hastie, Robert Tibshirani, Jerome Friedman “The Elements of Statistical Learning Data Mining, Inference, and Prediction”, Second Edition
6. Ian Witten, Frank Eibe and Mark A. Hall, "Data Mining: Practical Machine Learning Tools and Techniques”, Elsevier, 2011.
7. **NPTEL:**https://onlinecourses.nptel.ac.in/noc21_cs06/preview
   https://onlinecourses.nptel.ac.in/noc19_cs53/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION**	
1.1	Motivation for Data Mining - Data Mining Issues -Importance - Data Mining from a Database Perspective	2
1.2	Classification of Data Mining Systems – Major issues in Data Mining.	1
1.3	**Data Pre-processing**: Types of data, Data cleaning, Aggregation, Sampling	2
1.4	Feature subset selection, wrapper and filter methods.	2
2	**DATA OBJECTS AND ATTRIBUTE TYPES**	
2.1	Attribute, Nominal Attributes,Binary Attributes, Ordinal Attributes, Numeric Attributes,Discrete versus Continuous Attribute.	2
2.2	**Measuring the Central Tendency**: Mean, Median, and Mode Measuring the Dispersion of Data: Range, Quartiles, Variance, Standard Deviation, and Interquartile Range	1
2.3	**Measuring Data Similarity and Dissimilarity**: Data Matrix versus Dissimilarity Matrix, Proximity Measures for Nominal Attributes, Binary Attributes ,Ordinal Attributes	2
2.4	Dissimilarity of Numeric Data, Minkowski Distance , Dissimilarity for Attributes of Mixed Types , Cosine Similarity	2
2.5	**Association Rules**: Large Itemsets, Market Basket Analysis,Apriori Algorithm, Sampling Algorithm, Partitioning	2
2.6	**Pattern Mining:** Constraint-based pattern mining, Mining sequential patterns	2
3	**DECISION TREE-BASED ALGORITHMS**	
3.1	ID3, C 4.5 and C5.0, CART	2
3.2	Classification – Prediction – Voting, Bagging, Boosting	2
3.3	Boosting, Stacking, Cascading,	2
3.4	Random forest, Introduction to Semi Supervised learning	2
4	**CLUSTERING: HIERARCHICAL ALGORITHMS**	
4.1	Agglomerative Algorithms, Divisive Clustering	1
4.2	Minimum Spanning Tree, K -Means Clustering , K-Mediods	2
4.3	Nearest Neighbour Algorithm , PAM Algorithm.	1
4.4	**Clustering Large Databases**: BIRCH , DBSCAN, CURE Algorithm	2

Module No.	Topic	No. of Periods
5	**MINING DATA STREAMS**	
5.1	Challenges–Stream data model –	1
5.2	Sampling data in a stream,	2
5.3	Filtering streams: The Bloom Filter	1
5.4	Counting frequency items in a stream-The Count-Distinct Problem	2
5.5	TheFlajolet-Martin Algorithm.	1
6	**SEQUENCE MINING**	
6.1	Characteristics of Sequence Data, Problem Modelling,	3
6.2	Sequential Pattern Discovery, Timing Constraints,	1
6.3	Multivariate Time Series (MVTS) Mining: Importance of MVTSdata -	1
6.4	Sources of MVTS data - Mining MVTS data	2
	Total	**46**

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		Category	L	T	P	Credit
23DS630	**BIG DATA SYSTEMS**	PCC	3	1	0	4

Preamble

This course introduces Big Data processing techniques for business intelligence and analytics, focusing on MapReduce with Hadoop and advanced tools like Apache Spark, Pig, Hive, and HBase. Students will gain the skills to process, analyze, and derive insights from large datasets using emerging Big Data technologies.

Prerequisite

- 23DS340: Database Management

Course Outcomes

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

CO1	Appraise the business areas and real-world scenarios where BigData analytics and processing technologies can be applied.	Understand
CO2	Analyze and integrate Big Data technologies with cloud-based services, focusing on tools like Apache Spark and Google BigQueryfor large-scale data processing.	Analyze
CO3	Analyze solutions for Big Data applications using Hadoop ecosystemtools such as Pig, Hive, and HBase, while also exploring emerging technologies.	Analyze
CO4	Apply various NoSQL data models (key-value, columnar, document, and graph-based) for appropriate database management in Big Datascenarios.	Apply
CO5	Implement MapReduce and other parallel computing algorithms using Hadoop and Spark frameworks to efficiently process large datasets.	Apply
CO6	Integrate databases and perform schema mapping, ensuring information preservation and data consistency across distributed systems.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	S	S	M	S	L	S	-	S	-	S	M	M
CO2	S	S	S	M	S	-	-	-	-	-	-	-	-	S
CO3	S	S	M	S	M	M	-	-	M	-	-	-	M	S
CO4	S	M	S	M	S	-	-	-	-	-	-	-	-	S
CO5	S	S	S	S	S	-	-	-	-	-	M	-	S	S
CO6	M	S	M	M	S	-	-	-	-	-	-	-	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	20					10																		2	10				
CO2													5		10	20						25			2			15		
CO3													5	10		20							25		2			15		
CO4	5	10	20					50																		10	10			
CO5													10		20						50				2	5	10			
CO6	5	10	20						40																2	5	10			
Total (in %)	100						100						100						100						100					

Syllabus

PARALLEL AND DISTRIBUTED DATABASES: Introduction to parallel databases - Architecture and concepts of parallel databases - Parallel query evaluation and optimization - Introduction to
distributed databases (DDBMS) - DDBMS architecture and distributed database design - Distributed query processing and optimization

INTRODUCTION TO BIG DATA: Big Data challenges and characteristics – Types of big data (structured, semi-structured, unstructured) - NoSQL data models (Key-value, Document- based, Column-oriented, Graph-based) - SQL vs NoSQL databases – Big Data Applications (Microsoft Azure, Spark integration)

DATA MODELING AND DATABASE INTEGRATION: Data warehousing concepts – Schema directed data integration - Schema mapping and information preservation - Data exchange and automatic schema matching – Schema for multidimensional data models

NOSQL DATABASES: Key-Value Stores (Redis, Oracle Coherence) - Column-Oriented Stores (Cassandra, HBase) - Document-Oriented Stores (MongoDB, CouchDB) - Graph Databases (Neo4j, OrientDB)

BIG DATA PROCESSING FRAMEWORKS (MAP-REDUCE): Introduction to Apache Hadoop - Hadoop ecosystem - Concepts of HDFS - MapReduce programming model - Pig, Hive, Spark, Yarn,

INTRODUCTION TO DATA ANALYTICS: Overview of Data Analytics - Types of analytics (Descriptive, Diagnostic, Predictive, Prescriptive) and their applications - Basics of Statistical Analysis for Big Data - Analytics tools (Apache Spark, Google BigQuery, Kafka) - Machine Learning for Big Data (linear regression with Spark or BigQuery)

Reference Books & web resources

1. White, T. (2012). “Hadoop: The definitive guide”. O'Reilly Media, Inc. (Chapter: 1, 3, 4, 16, 17 & 19)
2. Elmasri, R., & Navathe, S. B. (2016). “Fundamentals of database systems seventh edition”. (Chapter: 18, 23 & 29)
3. Acharya, S., & Chellappan, S. (2019). “Big data and analytics”. Wiley. (Chapter: 1, 2, 4, 5, 6, 7, 8 & 12)
4. Warren, J., & Marz, N. (2015). “Big Data: Principles and best practices of scalable realtime data systems”. Simon and Schuster.
5. EMC Education Services (Ed.). (2014). “Data science and big data analytics: discovering, analyzing, visualizing and presenting data”. John Wiley & Sons.
6. Erl, T., Khattak, W., & Buhler, P. (2016). “Big data fundamentals: concepts, drivers & techniques”. Prentice Hall Press.
7. Ryza, S., Laserson, U., Owen, S., & Wills, J. (2017). “Advanced analytics with spark: patterns for learning from data at scale”. O'Reilly Media, Inc.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**PARALLEL AND DISTRIBUTED DATABASES**	
1.1	Introduction to parallel databases	1
1.2	Architecture and concepts of parallel databases	1

1.3	Parallel query evaluation and optimization	1
1.4	Introduction to distributed databases (DDBMS)	1
1.5	DDBMS architecture and distributed database design	1
1.6	Distributed query processing and optimization	1
2	**INTRODUCTION TO BIG DATA**	
2.1	Big Data challenges and characteristics	1
2.2	Types of big data (structured, semi-structured, unstructured)	1
2.3	NoSQL data models (Key-value, Document-based, Column-oriented, Graph-based)	2
2.4	SQL vs NoSQL databases	1
2.5	Big Data Applications (Microsoft Azure, Spark integration)	2
3	**DATA MODELING AND DATABASE INTEGRATION**	
3.1	Data warehousing concepts	1
3.2	Schema directed data integration	1
3.3	Schema mapping and information preservation	1
3.4	Data exchange and automatic schema matching	1
3.5	Schema for multidimensional data models	2
4	**NOSQL DATABASES**	
4.1	Key-Value Stores (Redis, DynamoDB)	2
4.2	Column-Oriented Stores (Cassandra, HBase)	2
4.3	Document-Oriented Stores (MongoDB, CouchDB)	2
4.4	Graph Databases (Neo4j, OrientDB)	2
5	**Big Data Processing Frameworks (Map-Reduce)**	
5.1	Introduction to Apache Hadoop and Hadoop ecosystem	1
5.2	Concepts of HDFS	1
5.3	MapReduce programming model	1
5.4	Pig, Hive, Spark, Yarn	5
6	**Introduction to Data Analytics**	
6.1	Overview of Data Analytics and Types of analytics (Descriptive, Diagnostic, Predictive, Prescriptive)	2
6.2	Basics of Statistical Analysis for Big Data	2
6.3	Analytics tools (Apache Spark, Google BigQuery, Khafka)	3
6.4	Machine Learning for Big Data (linear regression with Spark or BigQuery)	3
	Total	**45**

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23DS640	ETHICS FOR DATA SCIENCE	Category	L	T	P	Credit
		PCC	3	0	0	3

Preamble

This course will enable students to recognize the ethical issues when applying data science to real world problems and learn about the ethical aspects of data science, including privacy, plagiarism, intellectual property rights, piracy, security and confidentiality.

Prerequisite

- NIL

Course Outcomes

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

CO1	Understand key ethical concepts related to data science, including the balance between right and wrong in data-driven decision-making.	Understand
CO2	Explain privacy concerns and ethical issues surrounding data collection and usage, focusing on mechanisms to protect individual rights.	Understand
CO3	Describe ethical frameworks to address privacy and fairness issues in data preprocessing, ensuring responsible use of data.	Apply
CO4	Implement ethical modeling techniques to develop fair, transparent, and accountable predictive models.	Apply
CO5	Explain ethical evaluation techniques to interpret results and ensure transparency and fairness in data-driven systems.	Apply
CO6	Use ethical principles to manage the deployment of data science solutions, considering access rights and fair treatment for different groups.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	S	-	-	M	-	-	-	M	L
CO2	M	-	-	-	-	S	-	-	M	-	-	-	S	M
CO3	M	M	S	M	M	S	M	-	M	-	-	-	S	S
CO4	M	M	S	M	M	S	M	-	M	-	-	-	S	S
CO5	M	M	M	S	M	S	M	M	M	-	-	-	S	S
CO6	M	M	S	M	M	S	M	-	M	-	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	5	10																							5	5				
CO2	5	10																							5	5				
CO3		10	40						60				5												5	5	10			
CO4			20						40				5	10	10										5	5	10			
CO5													5	10	20						50					5	10			
CO6													5	10	20						50					5	20			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO DATA SCIENCE ETHICS - The Rise of Data Science (Ethics), Right and Wrong, Transparency in the Design Process: Model Cards, Data Cards. Data Science Ethics Equilibrium- The FAT Flow Framework for Data Science Ethics.

ETHICAL DATA GATHERING- Privacy as a Human Right- Privacy Mechanisms, Case study: Backdoors and Messaging Encryption-Dating, Happiness, and Ad.

ETHICAL DATA PREPROCESSING - Defining and Measuring Privacy, Re-identification - Defining and Selecting Variables Case study: Pregnancy and Face Recognition- Fair Relabelling.

ETHICAL MODELLING: Privacy, Preserving Data Mining, Discrimination-Aware Modelling Predicting Recidivism and Redlining, Bias and Fairness in Modelling, Comprehensible Models and Explainable AI, Including Ethical Preferences, Case Study - Self Driving Cars.

ETHICAL EVALUATION: Ethical Measurement, Ethical Interpretation of the Results, Case Study-Ethical Reporting.

ETHICAL DEPLOYMENT: Access to the System, Different Treatments for Different Predictions, Societal Impact, Case Study-Censoring Search and Face Recognition

Reference Books & web resources

1. Tales Rachel, DAVID MARTENS , “Data Science Ethics Concepts, Techniques and Cautionary”, Oxford university press, 2021. (Chapters 1 to 7)
2. Barocas, S., Hardt, M., & Narayanan, A. (2023). “Fairness and machine learning: Limitations and opportunities”. MIT press.
3. Mike Loukides, Hilary Mason and DJ Patil,”Ethics and Data Science”,O'Reilly Media; 1st edition (25 July 2018) .
4. Martens D. “Data science ethics: Concepts, techniques, and cautionary tales”. Oxford University Press; 2022 Mar 24.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO DATA SCIENCE ETHICS**	
1.1	Basic concepts	2
1.2	Challenges	1
1.3	Opportunities	1
1.4	The Rise of Data Science (Ethics), Right and Wrong	1
1.5	Data Science Ethics Equilibrium	1
1.6	Transparency in the Design Process: Model Cards, Data Cards.	1
1.7	The FAT Flow Framework for Data Science Ethics	1
2	**ETHICAL DATA GATHERING**	

Module No.	Topic	No. of Periods
2.1	Privacy as a Human Right	1
2.2	Privacy Mechanisms	1
2.3	Need to analyze Privacy	1
2.4	Factors influencing Data Privacy	1
2.5	Case study: Backdoors and Messaging Encryption-Dating, Happiness, and Ads	1
2.6	Perception / Individual Decision Making	1
2.7	Ethics in Decision Making	1
3	**ETHICAL DATA PRE-PROCESSING**	
3.1	Introduction	1
3.2	Defining and Measuring Privacy	1
3.3	Re-identification	1
3.4	Defining and Selecting Variables	1
3.5	Case study: Pregnancy and Face Recognition-Fair Relabelling	1
4	**Ethical Modelling: Privacy**	
4.1	Preserving Data Mining	2
4.2	Discrimination-Aware Modelling Predicting Recidivism and Redlining	1
4.3	Bias and Fairness in Modelling	1
4.4	Comprehensible Models	1
4.5	Explainable AI	1
4.6	Ethical Preferences, Case Study-Self-Driving Cars	1
5	**ETHICAL EVALUATION**	
5.1	Ethical Measurement	1
5.2	Ethical Interpretation of the Results	1
5.3	Case Study - Ethical Reporting	1
6	**ETHICAL DEPLOYMENT**	
6.1	Access to the System	2
6.2	Different Treatments for Different Predictions	1
6.3	Societal Impact	1

Module No.	Topic	No. of Periods
6.4	Case Study: Censoring Search and Face Recognition	1
	Total	**35**

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23DS670	DEEP LEARNING LAB	Category	L	T	P	Credit
		PCC	0	0	4	2

Preamble

The purpose of this course is to introduce students to deep learning concepts, including neural networks, optimization techniques, and model evaluation. Students will gain hands-on experience using frameworks like TensorFlow and PyTorch to implement CNNs, RNNs, and generative models, while exploring real-world applications and best practices in deep learning.

Prerequisite

- 23DS540- Machine Learning.

Course Outcomes

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

CO1	Design feedforward neural networks for various regression and classification tasks using Python.	Apply
CO2	Implement convolutional neural networks (CNNs) for image classification and analysis on real-world datasets.	Apply
CO3	Apply regularization techniques to improve the generalization of deep learning models.	Apply
CO4	Execute different optimization algorithms and evaluate their effectiveness in training deep learning models.	Apply
CO5	Construct recurrent neural networks (RNNs) to model and analyze sequential data.	Apply
CO6	Demonstrate generative models, attention mechanisms and transformers for advanced applications in natural language processing and image classification.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	S	M	-	L	L	-	L	-	S	S
CO2	S	S	S	M	S	M	L	L	L	L	L	L	S	S
CO3	S	S	S	L	S	-	-	-	-	-	-	-	S	M
CO4	S	S	S	L	S	-	-	-	-	-	-	-	S	M
CO5	S	S	S	M	S	M	L	L	L	L	L	L	S	S
CO6	S	S	S	M	S	M	L	L	L	-	L	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

1. **Neural Networks Basics:** Implement a simple feedforward neural network from scratch using NumPy -Visualize activations and layer connections.
2. **Deep Feedforward Networks and Backpropagation:** Code backpropagation in TensorFlow or PyTorch- Train and evaluate on a simple dataset.
3. **Activation Functions and Loss Functions:** Experiment with different activation functions and visualize loss curves -Understand the impact of each activation function on network convergence.
4. **Convolutional Neural Networks (CNNs):** Build a CNN from scratch, visualize feature maps, fine-tune pretrained models like ResNet, VGG, and Hugging Face

models to compare performance metrics, and implement YOLO for object detection to visualize and evaluate detection results.

5. **Regularization and Generalization Techniques:** Implement dropout and L1/L2 regularization, analyzing their effect on overfitting - Debug and analyze training vs. validation loss behavior.
6. **Optimization Techniques:** Compare optimization algorithms and implement gradient clipping and learning rate schedules - Explore debugging techniques for model convergence.
7. **Hyperparameter Tuning:** Conduct hyperparameter tuning using Grid Search and Random Search- Analyze the impact of hyperparameters on model performance.
8. **Model Evaluation and Metrics:** Implement evaluation metrics and visualize confusion matrices and ROC curves.
9. **Sequence Modeling and Temporal Data:** Build RNN models for sequence prediction or sentiment analysis- Explore advanced use cases like multivariate time series forecasting.
10. **Generative Models (GANs and VAEs):** Implement GANs for image generation and VAEs for data representation- Analyze latent space and quality of generated samples.
11. **Attention Mechanisms and Transformers:** Implement attention mechanisms and experiment with hybrid architectures- Explore Vision Transformers (ViT) for image classification tasks.

Capstone Project and Model Interoperability with ONNX:

- Build a project that integrates deep learning concepts, incorporating explainability techniques and addressing ethical concerns.Convert models between PyTorch and TensorFlow using ONNX for model interoperability.

Text Books

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning” (Adaptive Computation and Machine Learning Series), MIT Press, 2016.
2. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow”, O'Reilly Media, 2019.
3. François Chollet, “Deep Learning with Python”, Manning Publications, 2021.
4. Charu Aggarwal, “Neural Networks and Deep Learning: A Textbook”, Springer, 2023.

Course Designer:

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23DS680 BIG DATABASE SYSTEMS LAB

Category	L	T	P	Credit
PCC	0	0	4	2

Preamble

This lab course aims to give students hands-on experience with various types of big data systems and tools, including NoSQL databases, big data processing frameworks and tools. Students will explore different data storage models such as key-value, column-oriented, document, and graph databases and learn to work with data processing and machine learning tools in big data environments.

Prerequisite

- 23DS380: Relational Database Lab
- 23DS370: Data Structures Lab

Course Outcomes

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

CO1	Understand and differentiate various NoSQL databases, including key-value, column-oriented, document, and graph databases	Understand
CO2	Demonstrate data storage and retrieval operations using Oracle Coherence, HBase, MongoDB, and Neo4j.	Apply
CO3	Apply big data processing on large datasets using Hadoop MapReduce, Apache Hive, and Apache Spark	Apply
CO4	Implement real-time data streaming and ingestion using Apache Kafka, integrate other big data processing tools.	Apply
CO5	Execute machine learning tasks using Weka and interpret the results into meaningful insights.	Analyze
CO6	Design and complete a capstone project using NoSQL databases and big data tools.	Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	S	S	M	-	S	-	-	-	-	S	M
CO2	S	S	S	S	S	-	-	-	-	M	-	-	S	S
CO3	S	S	S	S	S	-	-	-	-	M	-	-	S	S
CO4	S	S	S	S	S	M	M	-	S	S	S	S	S	S
CO5	S	S	S	S	S	M	M	-	S	S	-	S	S	S
CO6	S	S	S	S	S	-	-	-	S	S	S	S	S	S

S- Strong; M-Medium; L-Low

List of Experiments

1. Introduction to NoSQL

Key-Value Database - Oracle Coherence

- CRUD operations in Oracle Coherence
- Implementing caching and replication strategies

Column-Oriented Database - HBase

- Performing CRUD operations in HBase
- Working with large datasets in HBase and understanding column families and regions

Document-Oriented Database - MongoDB

- CRUD operations and complex queries
- Aggregation framework in MongoDB

Graph Database - Neo4j
- Building and querying graphs in Neo4j
- Implementing relationships, traversals, and graph algorithms

2. Big Data Processing with Hadoop, Spark, and Hive

Hadoop - MapReduce
- Basic programs - Hadoop, HDFS, and MapReduce
- Writing MapReduce jobs for batch processing on Hadoop

Apache Hive –ETL(Extract Transform and Load)
- Data ingestion and ETL processes in Hive

Spark - Big Data Processing
- Data processing with Spark RDDs, DataFrames, and DataSets

3. Data Processing with Kafka

Streaming Data Transmission
- Processes to publish and retrieve messages within Kafka

Integrating Kafka with Big Data Tools
- Kafka streaming with Spark and data ingestion to HDFS or HBase

4. Machine Learning with Weka

Use the Weka tool for pre-processing in Machine Learning for Big Data
- Perform Classification, clustering, and association rules on large datasets using Weka

5. Capstone project

Design and complete a capstone project that applies a combination of NoSQL databases and big data tools to address a complex data-driven problem.

Reference Books & Web Resources

1. Tom White, "Hadoop: The Definitive Guide", 4th Edition, O'Reilly Media, 2015.
2. Edward Capriolo, Dean Wampler, and Jason Rutherglen, "Programming Hive", 1st Edition, Publisher: O'Reilly Media, 2012.
3. Lars George, "HBase: The Definitive Guide", 1st Edition,O'Reilly Media, 2011.
4. Neha Narkhede, Gwen Shapira, and Todd Palino, "Apache Kafka: The Definitive Guide", 1st Edition, O'Reilly Media, 2017.
5. Bill Chambers and Matei Zaharia "Spark: The Definitive Guide", 1st Edition, O'Reilly Media, 2018.
6. Nishant Neeraj, "Mastering Apache Cassandra", 1st Edition, Publishing, 2013.
7. Pramod J. Sadalage and Martin Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence",1st Edition,Addison-Wesley, 2012.

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23DSPA0	HIGH PERFORMANCE COMPUTING	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course introduces students to the architecture and programming techniques of high-performance computing (HPC) systems, focusing on parallelism across shared and distributed memory systems.

Prerequisite

- 21DS130: Computer Organization
- 21DS350: Operating Systems

Course Outcomes

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

CO1	Understanding the fundamentals of computer organization, including processor design, memory hierarchies, and system-level hardware architecture.	Understand
CO2	Apply advanced computational algorithms in a high-performance computing environment using shared memory and message-passing paradigms.	Apply
CO3	Analyze the efficiency of parallel algorithms, focusing on memory access patterns, data locality, and synchronization overhead.	Analyze
CO4	Apply parallel programs for multicore and GPU architectures utilizing OpenMP, MPI, and CUDA programming models.	Apply
CO5	Apply performance tuning techniques to optimize resource usage across different parallel architectures.	Apply
CO6	Analyze the trade-offs between different HPC architectures (such as CPU, GPU, and accelerators) in terms of power, scalability, and performance.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	L	L	L	L	L	-	-	-	-	-	-	M	L
CO2	L	M	S	M	M	M	-	-	-	-	-	-	S	L
CO3	L	S	M	S	M	M	-	-	-	-	-	-	S	L
CO4	L	M	S	M	S	M	-	-	-	-	-	-	S	L
CO5	L	M	M	S	S	M	-	-	-	-	-	-	S	L
CO6	L	S	M	M	M	S	-	-	-	-	-	-	S	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1						Assignment 1						CAT 2						Assignment 2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	10																							3	10				
CO2		10	30						50																3	3	10			
CO3	5	10		30						50															3	3		15		
CO4													5	10	10						25				3	3	10			
CO5														10	20						25				3	3	10			
CO6													5	10		30						50				3		15		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO HIGH PERFORMANCE COMPUTING (HPC): Definition of High-Performance Computing (HPC) and Need and scope of HPC in modern computing, Historical perspective and evolution of HPC systems - Moore's Law and its relevance to HPC Challenges of scaling computing performance - Types of HPC systems: Supercomputers, Clusters, Cloud-based HPC - Overview of high-performance hardware architectures - Processor topology and interconnection networks - Role of storage, power supply, and cooling in HPC design - HPC case studies: Applications in weather forecasting, molecular dynamics, and big data analytics - Demonstration of a basic HPC problem

PARALLEL PROGRAMMING BASICS: Shared memory vs distributed memory systems: Architectural differences Memory access patterns and data locality in shared memory systems - Distributed memory systems: Inter-process communication and synchronization - Introduction to parallel processing models (SPMD, SIMD) - Multicore processors: Basics and architectural implications - Cache coherence and memory consistency models in multicore systems - Parallel algorithm design principles - Decomposition techniques for parallel algorithms - Load balancing in parallel programs: Static vs dynamic load balancing - Communication overheads in parallel programs - Overview of basic parallel programming paradigms

MESSAGE PASSING INTERFACE (MPI): Introduction to the Message Passing Interface (MPI) standard - Concepts of message passing and process communication - Basic MPI functions: MPI_Init, MPI_Send, MPI_Recv, MPI_Finalize - Point-to-point communication and blocking vs non-blocking operations - Collective communication operations: Broadcast, Scatter, Gather, Reduce - Groups and communicators in MPI - Synchronization in MPI: Barriers and synchronization mechanisms - Error handling and debugging in MPI programs - Domain decomposition methods for scientific computing

OPENMP: Introduction to OpenMP: Fork-Join parallelism model - Basics of OpenMP directives for parallel regions - Work-sharing constructs in OpenMP: #pragma omp for, #pragma omp sections - Scheduling and controlling parallel loops - Synchronization in OpenMP: Critical sections, barriers, and atomic operations - Handling race conditions in OpenMP programs - OpenMP reductions: Using reduction clauses for aggregation operations **-** Thread-private variables and memory consistency in OpenMP-Nested parallelism in OpenMP

GPU COMPUTING WITH CUDA: Introduction to GPU architecture and CUDA programming - Differences between CPU and GPU processing models - CUDA programming model: Thread blocks, warps, and grid structures - Writing basic CUDA kernels for parallel computation - GPU memory hierarchy: Global, shared, and local memory - Managing memory and optimizing memory access patterns in CUDA - Synchronization and parallel reduction in CUDA - Using CUDA libraries for matrix algebra (e.g., cuBLAS)

PERFORMANCE OPTIMIZATION: Introduction to performance profiling tools (e.g., gprof, Valgrind, NVProf) - Measuring and analyzing the performance of parallel programs - Scalability metrics: Speedup, efficiency, and Amdahl's Law - Strong and weak scaling in parallel systems - Minimizing communication overheads in parallel programs - Techniques to reduce latency and improve data locality - Cache optimization techniques: Tiling, blocking, and loop unrolling

Reference Books & web resources

1. L. Hennessy and D. A. Patterson, "Computer Architecture: A Quantitative Approach", Morgan Kaufmann, 2017.

2. M. Quinn, “Parallel Programming in C with MPI and OpenMP”, McGraw-Hill Education, 2017.
3. A. Grama, et al., “Introduction to Parallel Computing”, Pearson, 2018.
4. G. Zaccone, “Python Parallel Programming Cookbook”, Packt Publishing, 2017.
5. [OpenMP Documentation](https://www.openmp.org)
6. [MPI Standard](https://www.mpi-forum.org)
7. [CUDA Programming Guide](https://developer.nvidia.com/cuda-toolkit)

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO HPC**	
1.1	Definition of High-Performance Computing (HPC) and Need and scope of HPC in modern computing, Historical perspective and evolution of HPC systems	1
1.2	Moore’s Law and its relevance to HPC - Challenges of scaling computing performance - Types of HPC systems: Supercomputers, Clusters, Cloud-based HPC	2
1.3	Overview of high-performance hardware architectures - Processor topology and interconnection networks - Role of storage, power supply, and cooling in HPC design	1
1.4	HPC case studies: Applications in weather forecasting, molecular dynamics, and big data analytics - Demonstration of a basic HPC problem (e.g., matrix multiplication)	1
2	**PARALLEL PROGRAMMING BASICS**	
2.1	Shared memory vs distributed memory systems: Architectural differences - Memory access patterns and data locality in shared memory systems	1
2.2	Distributed memory systems: Inter-process communication and synchronization - Introduction to parallel processing models (SPMD, SIMD)	1
2.3	Multicore processors: Basics and architectural implications - Cache coherence and memory consistency models in multicore systems	1
2.4	Parallel algorithm design principles - Decomposition techniques for parallel algorithms	1
2.5	Load balancing in parallel programs: Static vs dynamic load balancing Communication overheads in parallel programs	1
2.6	Overview of basic parallel programming paradigms	1
3	**MESSAGE PASSING INTERFACE (MPI)**	
3.1	Introduction to the Message Passing Interface (MPI) standard Concepts of message passing and process communication	1
3.2	Basic MPI functions: MPI_Init, MPI_Send, MPI_Recv, MPI_Finalize Point-to-point communication and blocking vs non-blocking operations	1
3.3	Collective communication operations: Broadcast, Scatter, Gather, Reduce - Groups and communicators in MPI	1
3.4	Synchronization in MPI: Barriers and synchronization mechanisms Error handling and debugging in MPI programs	1
3.5	Domain decomposition methods for scientific computing - Case study: Parallelizing a numerical method (e.g., solving linear equations) using MPI	1
3.6	Performance considerations for MPI programs - Optimizing communication and computation overlap in MPI applications	1

4	**OPENMP**	
4.1	Introduction to OpenMP: Fork-Join parallelism model - Basics of OpenMP directives for parallel regions	1
4.2	Work-sharing constructs in OpenMP: #pragma omp for, #pragma omp sections - Scheduling and controlling parallel loops	1
4.3	Synchronization in OpenMP: Critical sections, barriers, and atomic operations - Handling race conditions in OpenMP programs	1
4.4	OpenMP reductions: Using reduction clauses for aggregation operations - Thread-private variables and memory consistency in OpenMP	1
4.5	Nested parallelism in OpenMP - Case study: Parallelizing matrix multiplication with OpenMP	1
4.6	Performance tuning for OpenMP programs - Scalability and bottlenecks in shared memory parallel applications	1
5	**GPU COMPUTING WITH CUDA**	
5.1	Introduction to GPU architecture and CUDA programming - Differences between CPU and GPU processing models - CUDA programming model: Thread blocks, warps, and grid structures - Writing basic CUDA kernels for parallel computation	2
5.2	GPU memory hierarchy: Global, shared, and local memory - Managing memory and optimizing memory access patterns in CUDA	1
5.3	Synchronization and parallel reduction in CUDA - Using CUDA libraries for matrix algebra (e.g., cuBLAS)	1
5.4	Case study: Matrix multiplication on a GPU using CUDA - Optimizing the performance of CUDA programs	1
5.5	Performance tuning for GPU applications: Profiling tools and common optimization techniques - Case study: Performance comparison of CPU vs GPU for a given problem	1
6	**PERFORMANCE OPTIMIZATION**	
6.1	Introduction to performance profiling tools (e.g., gprof, Valgrind, NVProf) - Measuring and analyzing the performance of parallel programs	1
6.2	Scalability metrics: Speedup, efficiency, and Amdahl's Law - Strong and weak scaling in parallel systems	1
6.3	Minimizing communication overheads in parallel programs - Techniques to reduce latency and improve data locality	1
6.4	Cache optimization techniques: Tiling, blocking, and loop unrolling - Case study: Optimizing a memory-bound application	1
6.5	Power and energy optimization in HPC systems - Green computing and its importance in HPC environments	1
6.6	Case study: Performance tuning of a complex scientific application Comparison of performance metrics across CPU, MPI, OpenMP, and CUDA implementations	2
	Total	**36**

Course Designer:

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23DSPB0	MOBILE APPLICATION DEVELOPMENT	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course provides a comprehensive introduction to mobile app development, focusing on Android architecture, UI design, data storage, and cross-platform tools like PhoneGap and HTML5.

Prerequisite

- 23DS530 - Web Technology
- 23DS480 - Java Programming Lab

Course Outcomes

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

CO1	Explain the types, features, and challenges of mobile application development frameworks.	Understand
CO2	Describe Android features, architecture, and development environment, including installation and configuration processes.	Understand
CO3	Compare and contrast various Android APIs, focusing on their functionality and application in mobile app development.	Apply
CO4	Explain various user interface components and activities to create real-time mobile applications with efficient layouts and controls.	Apply
CO5	Implement services, data storage solutions, and location-based services for specific mobile app scenarios using SQLite, files, and content providers.	Apply
CO6	Analyze the practical applications of mobile applications in real-world scenarios, including cross-platform tools and multimedia integration.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	M	L	L	L	L	L	L	M	M	L
CO2	S	M	M	L	S	L	L	L	L	L	L	M	M	M
CO3	M	M	S	M	S	L	L	L	L	L	L	M	S	M
CO4	M	M	S	M	S	L	L	L	M	M	L	M	M	S
CO5	M	S	S	M	S	L	L	L	M	M	L	M	M	S
CO6	M	S	S	S	S	L	L	L	M	M	L	M	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10																							5	10				
CO2	10	10																							5	5				
CO3		10	20						50																5	5	10			
CO4			30						50				10												5	5	10			
CO5													10	10	30						40					5	10			
CO6														10	20	10						60					10	10		
Total (in %)	100						100						100						100						100					

Syllabus

MOBILE APPLICATION DEVELOPMENT FRAMEWORK: Types- Features- challenge. Android: Introduction – Architecture -Installation and configuration- ADE- APIs

USER INTERFACES: Components-views-Layouts and its types- Menus and its types – Dialogues and its types - Notifications and its types

DATA STORAGE: SQLite database-Files- shared preferences-Content Providers

LOCATION BASED SERVICES: Location Provider- Geo Coder- Map Multimedia: AudioVideo- Animations- Drawing.

PHONE GAP AND HTML5: Phone Gap Introduction – Architecture- Installation and configuration, HTML5 Introduction -Data list control- Validation feature -Application Cache in HTML 5.

EVENTS: Listener and its types-handler and its types. Geo location, Media, Storage.

Reference Books & web resources

1. Lauren Darcey and Shane Conder, “Android Wireless Application Development”, Pearson Education, 3rd edition. (2014) (Chapters 1 to 4).
2. RetoMeier, ”Professional Android Application Development”, Wrox, 2010.
3. Thomas Myer, ”Beginning PhoneGap,Wrox”, 2012.
4. Mark Murphy, ”Beginning Android,Apress”, 2009.
5. Rick Rogers et.al, ”Android – Application Development”, O‘Reilly, 2009.
6. Jochen Schiller, ”Mobile Communications”, Addison Wesley, 2011.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**MOBILE APPLICATION DEVELOPMENT FRAMEWORK**	
1.1	Types	2
1.2	Features and challenges	1
2	**ANDROID**	
2.1	Introduction	1
2.2	Architecture	2
2.3	ADE	1
2.4	APIs	1
3	**USER INTERFACES**	
3.1	Components, views	2
3.2	Layouts and its types	2
3.3	Menus and its types	1
3.4	Dialogues and its types	1
3.5	Notifications and its types	1

Module No.	Topic	No. of Periods
4	**DATA STORAGE**	
4.1	SQLite database, files	2
4.2	Shared preferences, Content Providers	2
5	**LOCATION BASED SERVICES**	
5.1	Location Provider	1
5.2	Geo coder	1
5.3	Map	1
6	**MULTIMEDIA**	
6.1	Audio	1
6.2	Video	1
6.3	Animations	1
6.4	Drawing	1
7	**PHONEGAP AND HTML5**	
7.1	PhoneGap Introduction	1
7.2	Architecture	2
7.3	HTML5 Introduction	1
7.4	Data list control	1
7.5	Validation feature	1
7.6	Application Cache in HTML 5	1
8	**EVENTS**	
8.1	Listener and its types	2
8.2	Handler and its types	1
	Total	**36**

Course Designer(s):

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23DSPC0 HEALTHCARE INFORMATICS

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This course provides an overview of healthcare informatics, focusing on the critical aspects of healthcare data, health information systems, and emerging technologies. The course aims to equip students with a practical understanding of how data science and IT support modern healthcare, and healthcare data privacy.

Prerequisite

Nil

Course Outcomes

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

CO1	Explain the role of healthcare informatics and health information systems in healthcare, and how they contribute to modern healthcare reform	Apply
CO2	Describe healthcare data, its sources, quality aspects, and the standards used to manage and share healthcare information	Apply
CO3	Utilize health information systems and data analytics to improve population health management, Tele-health, and patient engagement	Apply
CO4	Implement system acquisition, development, and support processes in a healthcare organization, considering the entire lifecycle	Apply
CO5	Use legal, privacy, and security principles to protect healthcare information systems and ensure data confidentiality	Apply
CO6	Assess emerging technologies such as AI, IoT, and Big Data, and their implications on healthcare IT governance and strategic planning	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	M	L	-	S	M	L	-	M	S
CO2	S	S	M	L	M	S	-	-	S	L	S	M	M	S
CO3	S	L	S	M	S	L	-	M	S	L	S	S	S	S
CO4	S	S	L	S	M	S	-	M	S	L	M	L	S	M
CO5	S	S	L	S	M	S	-	M	S	L	M	L	S	M
CO6	M	M	M	M	S	S	M	M	L	M	M	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10	10						30																5		10			
CO2	10	10	20						30																5		10			
CO3		10	20						40																5	5	10			
CO4													10		20						30				5	5	10			
CO5													10	10	20						30					5	10			
CO6														10	20						40					5	10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO HEALTHCARE INFORMATICS AND THE NATIONAL HEALTH IT LANDSCAPE- Introduction to Healthcare Informatics, National Health Information Technology Landscape, Electronic Health Records (EHR), Personal Health Records (PHR)

HEALTHCARE DATA: SOURCES, QUALITY, AND STANDARDS- Healthcare Data and Information
Data Sources: Clinical, Administrative, and External, Data Quality Dimensions, Healthcare Standards (HL7, ICD-10, SNOMED)

INFORMATION SYSTEMS TO SUPPORT POPULATION HEALTH MANAGEMENT- Population Health Management (PHM), Data analytics, dashboards, Tele health, Patient engagement in PHM

SYSTEM ACQUISITION, IMPLEMENTATION, AND SUPPORT IN HEALTHCARE IT- System Acquisition Process, Systems Development Life Cycle (SDLC), Post-implementation support, Case Study: Selecting an EHR for Dermatology Practice Case Study: Planning an EHR Implementation

PRIVACY, SECURITY, AND LEGAL ASPECTS IN HEALTHCARE IT- Privacy and Confidentiality, Legal frameworks: HIPAA, HITECH Act, Cybersecurity measures and risk management, Case Study: Breaching the Security of an Internet Patient Portal, Case Study: The Decision to Develop an IT Strategic Plan

EMERGING TRENDS AND IT GOVERNANCE IN HEALTHCARE- AI, IoT, and Big Data in Healthcare IT Governance and Strategic Planning, Case Study: Implementing Tele-psychiatry in a Community Hospital Emergency Department, Case Study: Assessing the Value and Impact of CPOE (Computerized Physician Order Entry)

Reference Books & web resources

1. Wager, K. A., Lee, F. W., & Glaser, J. P. (2017). “Health Care Information Systems: A Practical Approach for Health Care Management” (4th ed.). Jossey-Bass. (Chapters 1-6, 9,12-14).
2. Shortliffe, E. H., & Cimino, J. J. (2014). “Biomedical Informatics: Computer Applications in Health Care and Biomedicine” (4th ed.). Springer.
3. Hoyt, R. E., & Yoshihashi, A. (2017). “Health Informatics: Practical Guide for Healthcare and Information Technology Professionals (7th ed.)”. Informatics Education.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO HEALTHCARE INFORMATICS AND THE NATIONAL HEALTH IT LANDSCAPE**	
1.1	Introduction to Healthcare Informatics	2
1.2	National Health Information Technology Landscape	1
1.3	Electronic Health Records (EHR)	1
1.4	Personal Health Records (PHR)	1

Module No.	Topic	No. of Periods
2	**HEALTHCARE DATA: SOURCES, QUALITY, AND STANDARDS**	
2.1	Healthcare Data and Information	1
2.2	Data Sources: Clinical, Administrative, and External	1
2.3	Data Quality Dimensions	1
2.4	Healthcare Standards (HL7, ICD-10, SNOMED)	1
3	**Information Systems To Support Population Health Management**	
3.1	Population Health Management (PHM)	1
3.2	Data analytics, dashboards	1
3.3	Tele health	1
3.4	Patient engagement in PHM	1
4	**SYSTEM ACQUISITION, IMPLEMENTATION, AND SUPPORT IN HEALTHCARE IT**	
4.1	System Acquisition Process, ,	2
4.2	Systems Development Life Cycle (SDLC)	2
4.3	Post-implementation support	2
4.4	Case Study: Selecting an EHR for Dermatology Practice	1
4.5	Case Study: Planning an EHR Implementation	1
5	**PRIVACY, SECURITY, AND LEGAL ASPECTS IN HEALTHCARE IT**	
5.1	Privacy and Confidentiality	1
5.2	Legal frameworks: HIPAA, HITECH Act	1
5.3	Cybersecurity measures and risk management	1
5.4	Case Study: Breaching the Security of an Internet Patient Portal	1
5.5	Case Study: The Decision to Develop an IT Strategic Plan	1
6	**EMERGING TRENDS AND IT GOVERNANCE IN HEALTHCARE**	
6.1	AI, IoT, and Big Data in Healthcare IT Governance and Strategic Planning	2
6.2	Case Study: Implementing Tele-psychiatry in a Community Hospital Emergency Department	1
6.3	Case Study: Assessing the Value and Impact of CPOE (Computerized Physician Order Entry)	1
	Total	**30**

Course Designer:

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23DSPD0	EMBEDDED SYSTEMS	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

The course provides comprehensive knowledge of embedded systems design, programming, and real-time operating systems. Students will learn microcontroller architectures, programming in C, Assembly, and Java, and use development tools like emulators and debuggers.

Prerequisite

- 23DS130 - Digital Electronics
- 23DS350 - Operating Systems
- 23DS480 – Java Programming Lab

Course Outcomes

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

CO1	Understand the need for embedded systems and their design process.	Understand
CO2	Analyze the architecture and functioning of embedded processors and microcontrollers.	Analyze
CO3	Apply programming techniques using assembly, C, and Java for embedded systems.	Apply
CO4	Analyze the role of real-time operating systems and the importance of interrupts and multithreading.	Analyze
CO5	Apply embedded software development tools, including debuggers and emulators, for real-world projects.	Apply
CO6	Analyze design issues of embedded systems through case studies like digital cameras and smart cards.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	M	M	M	-	-	-	-	-	-	L	M	L
CO2	L	S	S	S	S	-	-	-	-	-	-	L	S	L
CO3	L	M	S	M	M	-	-	-	-	-	-	L	S	L
CO4	L	M	S	S	S	-	-	-	-	-	-	L	S	L
CO5	L	M	M	M	S	-	-	-	-	-	-	L	S	L
CO6	L	M	S	S	S	-	-	-	-	-	-	S	S	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	20																							3	10				
CO2	5	5	10	20						50															3	3		10		
CO3	5	10	20						50																3	3	10			
CO4													5	5	10	20						25			3	3		15		
CO5													5	10	10						50				3	3	10			
CO6														5	10	20						25				3		15		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO EMBEDDED SYSTEMS: Need for Embedded Systems - Introduction to embedded systems, their significance, and challenges - Embedded System Design Process, Steps involved in designing embedded systems - Microprocessors and Microcontrollers, Introduction to embedded processors: 8051, ARM, architecture and uses.

PROGRAMMING EMBEDDED SYSTEMS: Introduction to Assembly Language, Basic assembly programming for embedded systems - Introduction to C for Embedded Systems, C programming and its use in efficient embedded code design - Introduction to Java for Embedded Systems, Role of Java in embedded systems and its application - Efficient Code Techniques, Best practices in embedded programming using these languages.

REAL-TIME OPERATING SYSTEMS (RTOS): Inter-process Communication (IPC) in RTOS - Basics of IPC mechanisms in real-time systems - Interrupt Handling - Importance and implementation of interrupts: hardware and software interrupts - Multithreading Concepts in RTOS, Threads, task scheduling, and their significance in RTOS.

HARDWARE AND COMMUNICATION PROTOCOLS: Interface Design: Hardware and Software, Design methodologies for interfacing hardware with embedded systems - Communication Protocols: RTC Interfacing, Introduction to interfacing protocols like RTC, use in embedded designs - Programming Communication Interfaces, Hands-on programming of communication interfaces in embedded systems.

EMBEDDED SOFTWARE DEVELOPMENT: Layered Software Development, Understanding of FSM controllers and layered abstraction in embedded software - Device Driver Development, Concepts of developing device drivers for embedded systems - Real-Time Constraints and Programming, Methods to meet real-time constraints through efficient software design - Emulators and Debuggers in Embedded Development, Use of debugging tools and emulators in embedded software development.

EMBEDDED SYSTEM DESIGN TECHNIQUES & CASE STUDIES: Design Issues and Techniques in Embedded Systems - Key design issues and techniques in modern embedded systems - Case Studies: Robot, Digital Camera, Smart Cards, Real-world design case studies showcasing complete embedded system design processes.

Reference Books & web resources

1. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design”, 3rd edition, 2016.
2. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, Tata McGraw Hill, 3rd edition, 2017.
3. Frank Vahid and Tony Givargis, “Embedded System Design: A Unified Hardware/Software Introduction”, John Wiley & Sons, 2016.
4. [NPTEL - Embedded Systems] (https://nptel.ac.in/courses/106/105/106105193/)
5. [Coursera – Embedded Systems] (https://www.coursera.org/specializations/embedded-systems)

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO EMBEDDED SYSTEMS**	
1.1	Need for Embedded Systems, Introduction to embedded systems,	1

	their significance, and challenges	
1.2	Embedded System Design Process, Steps involved in designing embedded systems.	1
1.3	Microprocessors and Microcontrollers, Introduction to embedded processors: 8051, ARM, architecture and uses.	2
2	**PROGRAMMING EMBEDDED SYSTEMS**	
2.1	Introduction to Assembly Language, Basic assembly programming for embedded systems	2
2.2	Introduction to C for Embedded Systems, C programming and its use in efficient embedded code design.	2
2.3	Introduction to Java for Embedded Systems, Role of Java in embedded systems and its application.	2
2.4	Efficient Code Techniques, Best practices in embedded programming using these languages	2
3	**REAL-TIME OPERATING SYSTEMS (RTOS)**	
3.1	Inter-process Communication (IPC) in RTOS, Basics of IPC mechanisms in real-time systems	2
3.2	Interrupt Handling, Importance and implementation of interrupts: hardware and software interrupts.	2
3.3	Multithreading Concepts in RTOS, Threads, task scheduling, and their significance in RTOS	2
4	**HARDWARE AND COMMUNICATION PROTOCOLS**	
4.1	Interface Design: Hardware and Software, Design methodologies for interfacing hardware with embedded systems	2
4.2	Communication Protocols: RTC Interfacing, Introduction to interfacing protocols like RTC, use in embedded designs.	2
4.3	Programming Communication Interfaces, Hands-on programming of communication interfaces in embedded systems.	2
5	**EMBEDDED SOFTWARE DEVELOPMENT**	
5.1	Layered Software Development, Understanding of FSM controllers and layered abstraction in embedded software	2
5.2	Device Driver Development, Concepts of developing device drivers for embedded systems	2
5.3	Real-Time Constraints and Programming, Methods to meet real-time constraints through efficient software design.	2
5.4	Emulators and Debuggers in Embedded Development, Use of debugging tools and emulators in embedded software development.	2
6	**EMBEDDED SYSTEM DESIGN TECHNIQUES & CASE STUDIES**	
6.1	Design Issues and Techniques in Embedded Systems, Key design issues and techniques in modern embedded systems	2
6.2	Case Studies: Robot, Digital Camera, Smart Cards, Real-world design case studies showcasing complete embedded system design processes.	2
	Total	**36**

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23DSPE0 MARKETING ANALYTICS

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

The Marketing Analytics course outcomes are highly beneficial to students as they provide practical skills in data-driven decision-making, enabling them to understand and apply key tools and techniques to real-world marketing challenges. Students gain expertise in analyzing customer behaviours using Customer Relationship Management (CRM) systems.

Prerequisite

- 23DS470 - Predictive Analytics
- 23DS520 - Optimization Techniques
- 23DS830 - Business Analytics

Course Outcomes

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

CO1	Explain the conceptual foundation of Strategic CRM.	Understand
CO2	Analyze the evolution and growth of CRM using operational CRM tools and software.	Apply
CO3	Illustrate the impact and measuring the return on investment for social media marketing.	Apply
CO4	Apply marketing analytics models and metrics.	Apply
CO5	Implement the competitive analysis strategies and business strategies using strategic models.	Apply
CO6	Analyze product, service, and pricing analytics techniques	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	L	L	L	L	L	-	S	-	-	L	L	L	M
CO2	L	S	L	L	S	L	-	L	-	-	L	L	M	L
CO3	L	L	L	M	M	S	-	M	-	-	L	L	S	M
CO4	S	S	M	S	S	L	-	L	-	-	L	L	L	M
CO5	L	S	S	L	L	L	-	L	-	-	S	L	L	M
CO6	L	L	M	L	S	S	-	L	-	-	L	L	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10																							5	5				
CO2	5	5	30					10	40																		10			
CO3	5	5	30					10	40																5	5	10			
CO4													5	5	10											5	10			
CO5														10	20						50					5	10			
CO6														10	20	20						50				5	5	20		
Total (in %)	100						100						100						100						100					

Syllabus

CUSTOMER RELATIONSHIP MANAGEMENT (CRM): Conceptual Foundation: Strategic CRM Today - why managing customers more critical than Ever - benefits of customer value management approach - Evolution and Growth of CRM - Concepts of Customer value-Strategic CRM – **Operational CRM**: Software tools and Dashboard- CRM Software and Applications- CRM in Social Media.

MARKETING ANALYTICS: overview of Marketing Analytics - Models and metrics- Market Insight — Market data sources, sizing, PESTLE trend analysis, and porter five forces analysis — Market segment identification and positioning.

COMPETITIVE ANALYSIS AND BUSINESS STRATEGY: Competitor identification, Intelligence gathering, analysis and strategy- Analytics based strategy selection, with strategic models and metrics , Forecasting, balanced scorecard, and critical success factors.

PRODUCT, SERVICE AND PRICE ANALYTICS: Conjoint analysis model, decision tree model, portfolio resource allocation, Pricing techniques, pricing assessment, pricing for business markets, price discrimination.

DISTRIBUTION AND PROMOTION ANALYTICS: Retail location selection, distribution channel evaluation, and multi-channel distribution, Promotion budget estimation and allocation, promotion metrics for traditional media and social media.

SALES ANALYTICS: E Commerce sales mode, sales metrics, profitability metrics and support metrics.

Reference Books & web resources

1. V.Kumar, Werner Reinartz, “Customer Relationship Management Concept, Strategy, and Tools”, Third Edition, published by John Wiley & Sons, Inc., 2006. (Chapter 1,2,3,9,15)
2. Stephan Sorger, “Marketing Analytics – Strategic Models and Metrics”, Admiral Press, 2013.(Chapter 1-5,7,8,9,10,11)
3. Mark Jeffery, “Data Driven Marketing: The 15 Metrics Everyone in Marketing should know”, Wiley, 2013.
4. Paul W. Farris, Neil T. Bendle, Phillip E. Pfeifer, David J. Reibstein, “Marketing Metrics: The Definitive Guide to Measuring Marketing Performance”, Pearson FT press, 2012.
5. https://onlinecourses.nptel.ac.in/noc20_mg30/preview - NPTEL, By Prof. Swagato Chatterjee | IIT Kharagpur

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**CONCEPTUAL FOUNDATION OF STRATEGIC CRM**	
1.1	Conceptual Foundation of Strategic CRM	1
1.2	Importance of Customer Management	1
1.3	Customer Value Management Approach benefits	1

Module No.	Topic	No. of Periods
2	**EVOLUTION AND GROWTH OF CRM**	
2.1	Software Tools and Dashboards	2
2.2	CRM Implementation: In-house Development vs. Outsourcing	2
2.3	CRM Software Applications and Importance	2
3	**CRM IN SOCIAL MEDIA**	
3.1	The Social Media Landscape and Role in CRM	1
3.2	Impact of Word of Mouth on Brands	1
3.3	Measuring the ROI of Social Media Marketing	1
4	**MARKETING ANALYTICS MODELS AND METRICS**	
4.1	Market Data Sources and Sizing	2
4.2	PESTLE Analysis	2
4.3	Porter's Five Forces Analysis	2
4.4	Market Segment Identification and Positioning	2
4.5	Competitive Analysis: Intelligence Gathering and Strategy	1
5	**BUSINESS STRATEGY AND ANALYTICS**	
5.1	Analytics-based Strategy Selection	1
5.2	Forecasting and Critical Success Factors	1
5.3	Balanced Scorecard Approach	1
5.4	Design and Development in Marketing Analytics	1
6	**PRODUCT, SERVICE, AND PRICE ANALYTICS**	
6.1	Conjoint Analysis Model and Decision Tree Model	1
6.2	Portfolio Resource Allocation	1
6.3	Pricing Techniques and Assessment	1
6.4	Pricing for Business Markets and Price Discrimination	1
6.5	Distribution and Promotion Analytics	1
7	**SALES ANALYTICS**	
7.1	E-commerce Sales Model	1
7.2	Sales Metrics and Profitability Metrics	1
7.3	Support Metrics for Sales	1

Module No.	Topic	No. of Periods
7.4	Application of Marketing Analytics in Sales	1
	Total	**34**

Course Designer(s):

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23DSPF0 LARGE LANGUAGE MODELS

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This course provides an in-depth exploration of Large Language Models (LLMs), covering their architectures, training methodologies, and applications. Students will engage with transformer models, prompt engineering, and fine-tuning techniques.

Prerequisite

- 23DS210: Theory of Probability
- 23DS410: Linear Algebra
- 23DS540: Machine Learning

Course Outcomes

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

CO1	Explain the transformers and attention methods.	Understand
CO2	Describe the concept of Casual language modeling and GPT	Understand
CO3	Explore Masked Language modeling, pre-training and fine-tuning language models	Apply
CO4	Apply tokenization techniques and design a vanilla attention mechanism for long range context windows.	Apply
CO5	Implement optimization strategies, including LION, Adam, gradient clipping, and evaluate models benchmarks like MMLU and HELM.	Apply
CO6	Explore and apply fine-tuning methods like prompt tuning, multi-task fine-tuning, and evaluate with different frame works.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	S	S	S	L	-	-	-	-	-	-	L	M	M
CO2	M	S	M	S	M	-	-	-	-	-	-	L	M	S
CO3	M	M	S	S	S	-	-	-	-	-	-	L	S	M
CO4	S	S	M	S	M	L	-	-	-	-	-	L	S	S
CO5	S	S	M	S	M	L	-	-	-	-	-	L	S	S
CO6	M	S	S	M	S	-	-	-	-	-	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's Level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	15						20																	4	6				
CO2	10	15						30																	4	6				
CO3	10	20	20						50																4		15			
CO4													10		20						30					6	15			
CO5														10	20						40					6	15			
CO6													10	10	20						30				4		15			
Total (in %)	100						100						100						100						100					

Syllabus

Transformers: Introduction to transformers - Self-attention - cross-attention-Masked attention-Positional encoding, A deep dive into number of parameters, computational complexity and FLOPs

Language Modeling: Causal Language Modeling: What is a language model- Generative Pretrained Transformers (GPT) - Training and inference, Masked Language Modeling. Bidirectional Encoder Representations of Transformers (BERT) -Transfer Learning and Fine-Tuning, Pre-training vs Fine-tuning.

Tokenization and Datasets: BPE, SentencePiece, wordpiece, Bigger Picture: T5, A deep dive into text-to-text (genesis of prompting), taxonomy of models, road ahead, **Data:** Datasets, Pipelines, effectiveness of clean data, Architecture: Types of attention, positional encoding (PE) techniques, scaling techniques

Optimization and Training Techniques: Training: Revisiting optimizers, LION vs Adam, Loss functions, Learning rate schedules earning rate scheduling strategies: linear warm-up, cosine annealing, Gradient Clipping, typical failures during training,.

Fine-tuning and Evaluation–Prompt Tuning, Multi-task Fine-tuning, Parametric Efficient Fine-Tuning, Instruction fine-tuning datasets.MMLU, BigBench, HELM, OpenLLM.

Evaluation Frameworks: Training Large Models: Mixed precision training, Activation checkpointing,3D parallelism, ZERO, Bloom as a case study. Scaling Laws: Chinc,hilla, Gopher, Palm v2

Reference Books& web resource

1. Ian Goodfelllow, YoshuaBenjio, Aaron Courville, “Deep Learning”, The MIT Press. 2016
2. ZakariaSabti, “Prompt Engineering Demystified: Unleashing the Power of Large Language Models”, 2023
3. Andrew Radford, “Transformational Grammar: A First Course.”
4. Stephen Wolfram, “What is ChatGPT Doing … and Why Does It Work?”
5. https://stanford-cs324.github.io/winter2022/lectures/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**TRANSFORMERS**	
1.1	Introduction to transformers	1
1.2	Self-attention - cross- attention	1
1.3	Masked attention- Positional encoding	1
1.4	A deep dive into number of parameters, computational complexity and FLOPs	2
2	**LANGUAGE MODELING**	
2.1	Causal Language Modeling: What is a language model?-	1
2.2	Generative Pretrained Transformers (GPT) - Training and inference,	1

Module No.	Topic	No. of Periods
2.3	Masked Language Modeling : Bidirectional Encoder Representations of Transformers (BERT)	1
2.4	Transfer Learning and Fine-Tuning	1
2.5	Pre-training vs Fine-tuning	1
3	**TOKENIZATION AND DATASETS**	
3.1	BPE, SentencePiece, wordpiece, Bigger Picture: T5,	1
3.2	A deep dive into text-to-text (genesis of prompting), taxonomy of models, road ahead	2
3.3	Data: Datasets, Pipelines, effectiveness of clean data,	1
3.4	Architecture: Types of Attention, Positional Encoding (PE) Techniques, Scaling Techniques	2
4	**OPTIMIZATION AND TRAINING TECHNIQUES**	
4.1	Training: Revisiting optimizers, LION vs Adam,	2
4.2	Loss functions, Learning rate schedules	1
4.3	earning rate scheduling strategies: linear warm-up, cosine annealing,	1
4.4	Gradient Clipping, typical failures during training.	1
5	**FINE-TUNING AND EVALUATION**	
5.1	Prompt Tuning, Multi-task Fine-tuning	2
5.2	Parametric Efficient Fine-Tuning, Instruction fine-tuning datasets	2
6	**EVALUATION AND BENCHMARKING**	
6.1	MMLU, BigBench, HELM, OpenLLM	3
6.2	Evaluation Frameworks,	1
6.3	Training Large Models: Mixed precision training,Activation checkpointing,	1
6.4	3D parallelism, ZERO, Bloom as a case study	1
6.5	Scaling Laws: Chinc,hilla,	2
6.6	Gopher, Palm v2	2
	Total	**35**

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23DSPG0 **SOFT COMPUTING**

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

The course is designed to introduce students to soft computing concepts and techniques and foster their abilities in analysing soft computing-based solutions for real- world problems.

Prerequisite

- 23DS520 – Optimization Techniques
- 23DS540 – Machine Learning
- 23DS610 – Deep Learning
- 23DS620 – Data Mining

Course Outcomes

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

CO1	Apply the fuzzy logic operations and the process of fuzzification and defuzzification with a knowledge of fuzzy set theory	Apply
CO2	Apply fuzzy inference systems models, in practical scenarios for decision-making	Apply
CO3	Demonstrate various encoding techniques and reproduction methods in genetic algorithms	Apply
CO4	Use Genetic algorithm in solving optimization problem with different operators	Analyze
CO5	Select appropriate meta heuristics techniques, such as Simulated annealing, Tabu search, PSO, ACO and Bee colony optimization for specific applications	Analyze
CO6	Design and implement hybrid systems with neuro fuzzy modeling	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	M	M	L	L	L	L	L	-	L	S	S
CO2	S	S	M	S	M	L	L	L	L	L	-	L	S	S
CO3	S	S	M	M	M	L	L	L	L	L	-	L	S	S
CO4	S	S	S	S	M	L	L	L	L	L	-	L	S	S
CO5	S	S	S	S	M	L	L	L	L	L	-	L	S	S
CO6	S	S	M	M	M	L	L	L	L	L	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	5	10	20						25																4		10			
CO2	5	10	20						50																2	5	10			
CO3		10	20						25																4	5	10			
CO4													5	10		20							50		2			10		
CO5													5	10		20							25		4	5		10		
CO6														10	20							25			4	5	10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION: Overview of soft computing and historical development, Components of soft computing, Application of soft computing techniques in different areas

FUZZY SET THEORY: Basic Definitions and Terminologies, Fuzzy sets and relations, Membership functions, Fuzzification and Defuzzification techniques, Logic and Fuzzy systems, Applications of fuzzy inference systems in decision making

GENETIC ALGORITHM: Basic Concepts, Encoding: Binary, Permutation, Tree, Value , Fitness Function, Reproduction: Roulette Wheel, Boltzmann, Tournament, Rank, steady-state, Elitism, Operators : Selection, Crossover(Single point, Two point, Multi point, Uniform, Matrix, Partially Matched, Order and Cycle), Mutation (Flip, Swap, Inverse) – Applications to solve optimization problems

METAHEURISTIC TECHNIQUES: Simulated Annealing, Tabusearch, Particle swarm optimization (PSO), Ant colony optimization (ACO), Artificial Bee Colony Optimization - Applications

HYBRID SYSTEMS: ANFIS, Hybrid learning, Learning methods, Coactive Neuro Fuzzy modeling, Case studies

Reference Books & web resources

1. Ross Timothy J., "Fuzzy Logic with Engineering Applications", John Wiley and Sons,2010 (Chapters 2,3,4,5)
2. Rajasekaran S., Vijayalakshmi Pai G. A., Neural Networks, Fuzzy Logic and Genetic Algorithms, Prentice Hall, 2006 (Chapters 8,9)
3. Carlos, David, Gary, "Evolutionary algorithms for solving multi-objective problems", Springer 2007 (Chapters 10)
4. Jang J. S. R., Sun C. T. and Mizutani E., "Neuro-fuzzy and Soft Computing", PrenticeHall, 2010. (Chapters 12, 13)
5. David E. Goldberg, "Genetic Algorithms In Search, Optimization And Machine Learning", Pearson Education, 2002

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION**	
1.1	Overview of soft computing and historical development	1
1.2	Components of soft computing	1
1.3	Application of soft computing techniques in different areas	1
2	**FUZZY SET THEORY**	
2.1	Basic Definitions and Terminologies	1
2.2	Fuzzy sets and relations	1
2.3	Membership functions	1
2.4	Fuzzification and Defuzzification techniques	3
2.5	Logic and fuzzy systems	2
2.6	Applications of fuzzy logic in decision-making	1

Module No.	Topic	No. of Periods
3	**GENETIC ALGORITHM**	
3.1	Basic Concepts	1
3.2	Encoding: Binary, Permutation, Tree, Value , Fitness Function	1
3.3	Reproduction: Roulette Wheel, Boltzmann, Tournament, Rank, steady-state, Elitism	2
3.4	Operators : Selection, Crossover(Single point, Two point, Multi point, Uniform, Matrix, Partially Matched, Order and Cycle), Mutation (Flip, Swap, Inverse)	2
3.5	Applications to solve optimization problems	2
4	**META HEURISTIC TECHNIQUES**	
4.1	Simulated Annealing, Tabusearch	1
4.2	Particle swarm optimization (PSO)	1
4.3	Ant colony optimization (ACO)	2
4.4	Artificial Bee colony	2
4.5	Applications in clustering and routing problems	2
5	**HYBRID SYSTEMS**	
5.1	ANFIS – Hybrid Learning , Learning methods	2
5.2	Coactive Neuro Fuzzy modeling	2
5.3	Case studies	2
	Total	**34**

Course Designer(s):

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23DSPH0 MATHEMATICAL MODELING

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

The students will be able to learn the basic concepts of modelling and its different kinds, Fit data with different models for univariate and multivariate, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm. Also apply the concepts of fundamental theorem of asset pricing and Cox-Ross- Rubinstein (CRR) model, Brownian motion, martingales, risk neutral measure, Girsanov's theorem, Feynman-Kac formula, and bioinformatics.

Prerequisite

- 23DS110 Calculus
- 23DS220 Applied Statistics

Course Outcomes

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

CO1	Apply the concept of modelling in Fitting data with polynomials, splines	Apply
CO2	Apply the concept of modelling with regression analysis and time series models for univariate and multivariate	Apply
CO3	Apply the concepts of Mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm	Apply
CO4	Apply the concepts of fundamental theorem of asset pricing and Cox-Ross-Rubinstein (CRR) model	Apply
CO5	Apply the concepts of Brownian motion, martingales, risk neutral measure, Girsanov's theorem, Feynman-Kac formula	Apply
CO6	Apply the concepts of bioinformatics and model the real world problem using genetic algorithm and hidden markov models	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	L	L	L	L	-	-	-	-	S	M
CO2	S	S	S	M	L	M	M	L	L	-	L	L	S	S
CO3	S	M	S	M	M	L	L	-	L	-	L	L	S	M
CO4	S	M	S	M	M	L	M	L	-	-	L	-	S	S
CO5	S	M	S	S	L	L	M	-	L	-	L	-	S	S
CO6	S	S	S	S	M	M	L	-	L	-	L	-	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	4	10	20						30																4	10				
CO2	4	10	20						30																2		14			
CO3	2		30						40																	5	14			
CO4													4	10	20						30				2		14			
CO5													4	10	20						30					5	14			
CO6													2		30						40				2		14			
Total (in %)	100						100						100						100						100					

Syllabus

EMPIRICAL MODELING WITH DATA FITTING: Introduction to Modeling - Modeling process, Overview of different kinds of model. Error function, least squares method; fitting data with polynomials and splines.

CAUSAL MODELING AND FORECASTING: Introduction, Modeling the causal time series, forecasting by regression analysis, predictions by regression. Planning, development and maintenance of linear models, trend analysis, modeling seasonality and trend, trend removal and cyclical analysis, decomposition analysis. Modeling financial time series. Econometrics and time seriesmodels. Non seasonal models: ARIMA process for univariate and multivariate.

PORTFOLIO MODELING AND ANALYSIS: Portfolios, returns and risk, risk- reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM).

DISCRETE-TIME FINANCE: Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and fundamental theorem of asset pricing, Cox- Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives.

STOCHASTIC CALCULUS: Brownian motion, martingales, Itô‟s formula, Itô integral, risk-neutral measure, SDE; Risk-neutral measure, Girsanov's theorem for change of measure, martingale representation theorems, representation of Brownian martingales, Feynman-Kac formula.

MODELING WITH BIOINFORMATICS: Introduction, Biological data- types, mode of collection, documentation and submission. Sequence alignment- Definition, significance, dot matrix method, dynamic programming- Global and local alignment tools, scoring matrices and gap penalties. Multiple sequence alignment: Iterative methods. Genetic algorithm, Hidden Markovian models, statistical methods, position specific scoring matrices.

Reference Books & web resources

1. B. Barnes and G. R. Fulford (2021), “Mathematical Modelling with Case Studies: Using Maple and MATLAB, Third Edition".
2. Edward A. Bender (2022), “An Introduction to Mathematical Modeling: A Course in Mechanics"
3. Christos H. Skiadas and Ioannis Dimotikalis (2021), "Mathematical Modelling and Applications in Elements of Finance".
4. Vladimir Mityushev and Wojciech Nawalaniec (2022), "Introduction to Mathematical Modeling and Computer Simulations".
5. Cornelis W. Oosterlee and Lech A. Grzelak (2019) “Mathematical Modelling and Computation in Finance: With Exercises and Python and MATLAB Computer Codes"
6. Giordano F. R., Weir M. D., and Fox W. P., “A First Course in Mathematical Modeling”. Brooks/Cole, Belmont, 2014.
7. Christoffersen P., “Elements of Financial Risk Management”, Academic Press, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**EMPIRICAL MODELING WITH DATA FITTING**	
1.1	Introduction to Modeling - Modeling process	1
1.2	Overview of different kinds of model.	1
1.3	Error function	1
1.4	Least squares method	2

Module No.	Topic	No. of Periods
1.5	Fitting data with polynomials and splines	2
2	**CAUSAL MODELING AND FORECASTING**	
2.1	Introduction, Modeling the causal time series	1
2.2	Forecasting by regression analysis, predictions by regression.	1
2.3	Planning, development and maintenance of linear models,	1
2.4	Trend analysis, modeling seasonality and trend, trend removal and cyclical analysis, decomposition analysis	1
2.5	Modeling financial time series.	1
2.6	Econometrics and time series models.	1
2.7	Non seasonal models: ARIMA process for univariate and multivariate	2
3	**PORTFOLIO MODELING AND ANALYSIS**	
3.1	Portfolios, returns and risk, risk- reward analysis	1
3.2	Asset pricing models, mean variance portfolio optimization	1
3.3	Markowitz model and efficient frontier calculation algorithm	1
3.4	Capital Asset Pricing Models (CAPM)	1
4	**DISCRETE-TIME FINANCE**	
4.1	Pricing by arbitrage, risk-neutral probability measures	1
4.2	Valuation of contingent claims, and fundamental theorem of asset pricing	1
4.3	Cox- Ross-Rubinstein (CRR) model	1
4.4	Pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives	2
5	**STOCHASTIC CALCULUS**	
5.1	Brownian motion, martingales	1
5.2	Itô"s formula, Itô integral, risk-neutral measure, SDE	1
5.3	Risk-neutral measure, Girsanov's theorem for change of measure	2
5.4	Martingale representation theorems, representation of Brownian martingales, Feynman-Kac formula	2
6	**MODELING WITH BIOINFORMATICS**	
6.1	Introduction, Biological data- types, mode of collection, documentation and submission	1
6.2	Sequence alignment- Definition, significance, dot matrix method	1
6.3	Dynamic programming- Global and local alignment tools, scoring matrices and gap penalties	1
6.4	Multiple sequence alignment: Iterative methods	1

Module No.	Topic	No. of Periods
6.5	Genetic algorithm, Hidden Markovian models, statistical methods, position specific scoring matrices	2
	Total	**36**

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		Category	L	T	P	Credit
23DSPJ0	**GRAPH ALGORITHMS**	PEC	3	0	0	3

Preamble

This course will enable students to learn basic concepts of graphs and time-space complexity. Apply the different types of algorithms of shortest path for graphs. Apply the concepts of physical design algorithms and to learn partitioning of circuits. Learn the Global routing algorithms.

Prerequisite

- 23DS230: Graph Theory
- 23DS430: Design and Analysis of Algorithms

Course Outcomes

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

CO1	Understand the basic concepts of graphs with algorithm time space complexity	Understand
CO2	Apply the different types of algorithms for shortest path of various kinds of graphs.	Apply
CO3	Apply and model the plane sweep algorithm, Max min cut theorem and The Edmonds – Karp algorithm	Apply
CO4	Design the concepts of Physical algorithms.	Apply
CO5	Apply the concept of Partitioning the circuits.	Apply
CO6	Apply the different types of Global routing algorithms for Integer Programming Problem.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	M	M	-	L	L	L	M	M	-	S	M
CO2	S	S	M	M	M	L	-	-	M	M	M	M	M	S
CO3	S	S	S	S	M	-	L	M	M	M	M	L	S	M
CO4	M	M	S	-	M	-	M	L	L	L	M	L	M	S
CO5	M	M	S	M	M	M	L	M	M	-	M	-	M	S
CO6	S	M	S	-	S	M	L	M	M	M	M	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	4	10						20																	2	10				
CO2	2		40					20	30																2		20			
CO3	4	10	30						30																2	5	10			
CO4													4	10	20					10	20				2		20			
CO5													2		30					10	20				2		10			
CO6													4	10	20					20	20					5	10			
Total(in %)	100						100						100						100						100					

Syllabus

BASIC CONCEPTS: Graphs – representations, planar graphs- Euler's formula, crossing number, doubly connected edge list data structure, Algorithm complexity – time and space.

SHORTEST PATH ALGORITHMS: Properties for shortest path - The Bellman-Ford algorithm – Single source shortest path in directed acyclic graphs – Dijkstra's algorithm – Difference constraints and shortest paths – shortest paths and matrix multiplication – The Floyd Warshall Algorithm – Johnson's algorithm for sparse graphs.

NETWORK FLOW: Flow networks and Flows – Flow networks with multiple sources and sinks, The Ford – Fulkerson Method, Augmenting paths – Max Flow min cut theorem, The Edmonds – Karp algorithm.

PHYSICAL DESIGN: Classes of graphs in Physical design – Relationship between Graph Classes – Algorithms for Interval graphs, Permutation graphs & Circle graphs.

PARTITIONING: Classification of Partitioning Algorithms – Kernighan-Lin Algorithm – Fiduccia-Mattheyses Algorithm - Goldberg and Burstein Algorithm – Component Replication – Ratio Cut.

GLOBAL ROUTING: Classification of Global Routing Algorithm – Lee's Algorithm, Soukup's Algorithm – Hadlock's Algorithm – Maze routing Algorithm – Steiner Tree Algorithms.

Reference Books & web resources

1. Thomas H. Cormen, Charles E. Leiserson, and Ronald LRivest, — Introduction to Algorithms, Fourth Edition, MIT Press, 2022.
2. Naveed A. Sherwani - Algorithms for VLSI Physical Design Automation Springer Publication, 2013.
3. Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin Network Flows: Theory, Algorithms, and Applications, Prentice Hall, 1993.
4. https://onlinecourses.nptel.ac.in/noc24_cs70/preview
5. https://neo4j.com/blog/top-13-resources-graph-theory-algorithms/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**BASIC CONCEPTS**	
1.1	Graphs – representations, planar graphs	1
1.2	Euler's formula, crossing number	2
1.3	Algorithm complexity – time and space	2
2	**SHORTEST PATH ALGORITHMS**	
2.1	Properties for shortest path, The Bellman-Ford algorithm	2
2.2	Single source shortest path in directed acyclic graphs, Dijkstra's algorithm	1
2.3	Difference constraints and shortest paths – shortest paths and matrix multiplication	2

Module No.	Topic	No. of Periods
2.4	The Floyd Warshall Algorithm, Johnson's algorithm for sparse graphs.	2
3	**NETWORK FLOW**	
3.1	Flow networks and Flows	1
3.2	Flow networks with multiple sources and sinks	1
3.3	The Ford – Fulkerson Method, Augmenting paths	2
3.4	Max Flow min cut theorem, The Edmonds – Karp algorithm.	2
4	**PHYSICAL DESIGN**	
4.1	Classes of graphs in Physical design	2
4.2	Relationship between Graph Classes	1
4.3	Algorithms for Interval graphs, Permutation graphs & Circle graphs	3
5	**PARTITIONING**	
5.1	Classification of Partitioning Algorithms	1
5.2	Kernighan-Lin Algorithm	2
5.3	Fiduccia-Mattheyses Algorithm, Goldberg and Burstein Algorithm.	2
5.4	Component Replication, Ratio Cut.	1
6	**GLOBAL ROUTING**	
6.1	Classification of Global Routing Algorithm	1
6.2	Lee's Algorithm, Soukup's Algorithm	2
6.3	Hadlock's Algorithm, Maze routing Algorithm	2
6.4	Steiner Tree Algorithms	1
	Total	**36**

Course Designer(s):

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23DSPK0	EXPLAINABLE ARTIFICIAL INTELLIGENCE	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course provides an overview of Explainable AI (XAI) techniques, focusing on the importance of transparency and interpretability in machine learning models. It introduces interpretable models, model-agnostic methods, and local and global interpretability techniques, with real-world applications.

Prerequisite

- 23DS540: Machine Learning
- 23DS610: Deep Learning

Course Outcomes

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

CO1	Explain the importance of interpretability in machine learning models and understand the trade-offs with model accuracy.	Apply
CO2	Describe interpretable models such as linear models and decision trees to provide transparent predictions.	Apply
CO3	Implement model-agnostic methods to interpret black-box models using techniques such as Permutation Feature Importance and PDP.	Apply
CO4	Utilize local interpretability techniques, including LIME and SHAP, to provide explanations for individual predictions.	Apply
CO5	Differentiate between local and global interpretability methods and apply them to real-world scenarios.	Analyze
CO6	Assess ethical implications in AI systems, focusing on bias detection and fairness in interpretable models.	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	M	M	L	L	L	L	L	L	L	S	M
CO2	S	S	M	M	L	L	L	L	L	L	L	L	S	M
CO3	S	S	M	M	M	L	L	L	L	L	L	L	S	S
CO4	S	S	M	S	M	L	L	L	L	L	L	L	S	S
CO5	M	S	S	S	L	M	L	L	L	L	L	L	S	M
CO6	S	M	S	M	M	M	M	S	L	L	L	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	10	10						30																4		10			
CO2	10	10	20						30																4		10			
CO3		10	20						40																4	5	10			
CO4													10	10	10										4	5	10			
CO5													10	10	10	10					30	20			2	5		10		
CO6														10	10	10					30	20			2	5		10		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO INTERPRETABLE MACHINE LEARNING- Definition of interpretability, Why interpretability matters in machine learning, Trade-offs between accuracy and interpretability, Case Study: Real-world impacts of interpretability in sensitive domains (e.g., healthcare, finance)

INTERPRETABLE MODELS- Linear models and Generalized Linear Models, Decision trees and rule-based models, k-Nearest Neighbors (k-NN), Naive Bayes classifiers, Case Study: Using decision trees to explain credit scoring models

MODEL-AGNOSTIC INTERPRETABILITY METHODS- Permutation Feature Importance, Partial Dependence Plots (PDP), Accumulated Local Effects (ALE), Individual Conditional Expectation (ICE) plots, Case Study: Applying permutation feature importance in a fraud detection model

LOCAL INTERPRETABILITY TECHNIQUES- Local Surrogate Models (LIME), Shapley Values and SHAP explanations, Counterfactual Explanations, Anchors for decision rules, Case Study: Counterfactual explanations for loan approval decisions in banking systems

GLOBAL VS. LOCAL INTERPRETABILITY- Differences between global and local methods, Global surrogate models, Visualizing machine learning models, Feature importance and feature interactions, Case Study: Global vs. local interpretability for image classification in healthcare applications

ETHICAL IMPLICATIONS AND CHALLENGES- Interpretability in healthcare, finance, and legal systems, Bias detection and fairness in AI, Ethical challenges in deploying interpretable models, Future directions in Explainable AI research, Case Study: Ethical implications of explainable AI in healthcare diagnosis models

Reference Books & web resources

1. Molnar, Christoph. “Interpretable Machine Learning: A Guide for Making Black Box Models Explainable”, 2022. (Chapters 1 to 9).
2. Michael Munn and David Pitman, “Explainable AI for Practitioners”, O’Reilly Media, 2022.
3. Thampi A. “Interpretable AI: Building Explainable Machine Learning Systems”, Leanpub, 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO INTERPRETABLE MACHINE LEARNING**	
1.1	Definition of interpretability	1
1.2	Why interpretability matters in machine learning	1
1.3	Trade-offs between accuracy and interpretability	1
1.4	Case Study: Real-world impacts of interpretability in sensitive domains (e.g., healthcare, finance)	1
2	**INTERPRETABLE MODELS**	
2.1	Linear models and Generalized Linear Models	2

Module No.	Topic	No. of Periods
2.2	Decision trees and rule-based models	1
2.3	k-Nearest Neighbors (k-NN)	1
2.4	Naive Bayes classifiers	1
2.5	Case Study: Using decision trees to explain credit scoring models	1
3	**Model-Agnostic Interpretability Methods**	
3.1	Permutation Feature Importance	2
3.2	Partial Dependence Plots (PDP)	2
3.3	Accumulated Local Effects (ALE)	1
3.4	Individual Conditional Expectation (ICE) plots	1
3.5	Case Study: Applying permutation feature importance in a fraud detection model	1
4	**Local Interpretability Techniques**	
4.1	Local Surrogate Models (LIME)	2
4.2	Shapley Values and SHAP explanations,	1
4.3	Counterfactual Explanations	1
4.4	Anchors for decision rules	1
4.5	Case Study: Counterfactual explanations for loan approval decisions in banking systems	1
5	**Global vs. Local Interpretability**	
5.1	Differences between global and local methods	2
5.2	Global surrogate models	1
5.3	Visualizing machine learning models	1
5.4	Feature importance and feature interactions	1
5.5	Case Study: Global vs. local interpretability for image classification in healthcare applications	1
6	**Ethical Implications and Challenges**	
6.1	Interpretability in healthcare, finance, and legal systems	2
6.2	Bias detection and fairness in AI	1
6.3	Ethical challenges in deploying interpretable models	1
6.4	Future directions in Explainable AI research	1
6.5	Case Study: Ethical implications of explainable AI in healthcare diagnosis models	1
	Total	**35**

Course Designer:

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		Category	L	T	P	Credit
23DSPL0	**GAME THEORY**	PEC	3	0	0	3

Preamble

It equips students with foundational and advanced concepts in strategic decision-making. Through topics like Nash equilibrium, cooperative games, and mechanism design, students will gain practical skills to apply game theory in data-driven fields such as economics, business, and algorithmic decision-making.

Prerequisite

- 23DS210: Theory of Probability
- 23DS410: Linear Algebra

Course Outcomes

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

CO1	Explain foundational concepts of game theory, including Nash equilibrium and strategic form games.	Understand
CO2	Analyze extensive form games and their applications in decision-making.	Analyze
CO3	Apply cooperative game theory concepts, such as the Shapley value and core.	Apply
CO4	Apply principles from mechanism design theory to design effective mechanisms.	Apply
CO5	Apply models of bargaining and negotiation and how they can be applied to models of competition.	Apply
CO6	Analyze the societal implications of game-theoretic models in real-world scenarios.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	M	-	-	L	-	-	-	-	S	M
CO2	S	S	M	S	M	L	-	L	-	-	-	-	S	M
CO3	S	S	M	S	-	-	L	-	-	-	-	-	S	M
CO4	M	M	S	M	S	-	-	-	-	-	L	-	S	M
CO5	M	M	S	S	S	-	-	-	-	-	-	L	S	M
CO6	S	S	S	M	-	S	L	-	-	M	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	20						25																	2	10				
CO2									25				10			20						50			2			15		
CO3													5	10	20						25				2	5	10			
CO4													5	10	20						25				2	5	10			
CO5	5	10	20																						2	5	10			
CO6	5	10		20						50																5		15		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO GAME THEORY: Definition of Game Theory -Rational Choice and Utility Functions - Strategic vs. Extensive Form Games - Examples: Cournot and Bertrand competition models

STRATEGIC FORM GAMES: Pure and Mixed Strategy Nash Equilibria - Examples from economics, business, environment, military, market - Best Response Functions and Dominated Actions - Existence and Computation of Nash Equilibria - Zero-Sum Games and Minimax Theorem - Illustrations: Electoral competition, Vickrey auctions, Cournot competition

EXTENSIVE FORM GAMES: Games with Perfect Information -Backward Induction -Nash and Subgame Perfect Equilibrium - Repeated Games (Introduction) - Illustrations: Sequential bargaining, monopolistic industry entry

COOPERATIVE GAMES: Transferable Utility Games - The Core and Shapley Value -Nash Bargaining Solution

MECHANISM DESIGN AND AUCTIONS: Introduction to Mechanism Design -Social Choice Functions and Incentive Compatibility - Gibbard-Satterthwaite Theorem -Vickrey-Clarke-Groves (VCG) Mechanism - Optimal Mechanisms and Myerson Auction

ADVANCED TOPICS: Bayesian Games and Incomplete Information **-** Evolutionary Stable Strategies (ESS) **-** Applications to Population Games

Reference Books & web resources

1. Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani, (2011). “Algorithmic Game Theory”. Cambridge University Press.
2. Osborne, M. J. (2004). “An Introduction to Game Theory”. Oxford University Press google scholar, 2, 672-713. (Chapter: 2, 4, 9)
3. Anna R. Karlin and Yuval Peres, “Game Theory, Alive,” American Mathematical Society, Apr 27, 2017, ISBN-13: 978-1470419820.
4. Martin J. Osborne and Ariel Rubinstein, "A Course in Game Theory", MIT Press, 2016 (New Edition)
5. Siddharth Barman and Y. Narahari, “Game Theory Lecture Notes” Available online at https://lcm.csa.iisc.ernet.in/gametheory
6. Kevin Leyton-Brown and Yoav Shoham, "Essentials of Game Theory: A Concise, Multidisciplinary Introduction", Morgan & Claypool Publishers, 2016
7. E. N. Barron, "Game Theory: An Introduction" (2nd Edition), Wiley, 2017

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO GAME THEORY**	
1.1	Definition of Game Theory	1
1.2	Rational Choice and Utility Functions	1
1.3	Strategic vs. Extensive Form Games	1
1.4	Examples: Cournot and Bertrand competition models	2
2	**STRATEGIC FORM GAMES**	
2.1	Pure and Mixed Strategy Nash Equilibria	2

Module No.	Topic	No. of Periods
2.2	Examples from economics, business, environment, military, market	1
2.3	Best Response Functions and Dominated Actions	1
2.4	Existence and Computation of Nash Equilibria	2
2.5	Zero-Sum Games and Minimax Theorem	1
2.6	Illustrations: Electoral competition, Vickrey auctions, Cournot competition	2
3	**EXTENSIVE FORM GAMES**	
3.1	Games with Perfect Information	1
3.2	Backward Induction	1
3.3	Nash and Subgame Perfect Equilibrium	2
3.4	Repeated Games (Introduction)	1
3.5	Illustrations: Sequential bargaining, monopolisticindustry entry	2
4	**COOPERATIVE GAMES**	
4.1	Transferable Utility Games	1
4.2	The Core and Shapley Value	2
4.3	Nash Bargaining Solution	1
5	**MECHANISM DESIGN AND AUCTIONS**	
5.1	Introduction to Mechanism Design	1
5.2	Social Choice Functions and Incentive Compatibility	1
5.3	Gibbard-Satterthwaite Theorem	1
5.4	Vickrey-Clarke-Groves (VCG) Mechanism	1
5.5	Optimal Mechanisms and Myerson Auction	2
6	**ADVANCED TOPICS**	
6.1	Bayesian Games and Incomplete Information	1
6.2	Evolutionary Stable Strategies (ESS)	1
6.3	Applications to Population Games	1
	Total	**34**

Course Designer(s):

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23DSPM0 SOCIAL MEDIA ANALYTICS

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This course aims to provide students with the knowledge of key concepts in social media analytics, focusing on the representation of knowledge using ontology and the concept of the Semantic Web and explore the practical and theoretical aspects of analyzing social network data, performing extraction, reasoning, and applying it to real-world optimization, prediction, and evaluation problems.

Prerequisite

- 23DS230 **-** Graph Theory
- 23DS420 - Predictive Analytics

Course Outcomes

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

CO1	Understand and explain the basic concepts of the Semantic Web.	Understand
CO2	Describe key concepts in network analysis	Understand
CO3	Apply data extraction techniques to the social network data	Apply
CO4	Analyse and examine with aggregated social network data using ontologies.	Analyze
CO5	Compare and contrast various methods in knowledge representation for social networks.	Apply
CO6	Identify the application area of optimization, prediction and evaluation in real world scenario.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L	M	L	L	M	-	L	S	M	L	M
CO2	S	S	M	L	M	L	M	M	-	L	S	L	M	L
CO3	M	S	S	M	L	M	-	-	-	L	S	M	L	M
CO4	M	M	S	S	M	S	L	-	-	L		S	L	M
CO5	L	M	M	M	S	M	L	M	-	L	L	S	S	M
CO6	L	M	M	M	S	M	-	-	-		S	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	20						20																	5	10				
CO2	10	20						30																	5	10				
CO3	5	5	30						50																		15			
CO4														5	5	20						40						20		
CO5														10	20						20						15			
CO6														10	10	20						40						20		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO THE SEMANTIC WEB : Limitations of the Current Web - Address issues: lack of structured data, semantic ambiguity, and human dependency for data interpretation - Development of the Semantic Web- technologies RDF and OWL - emergence of the Social Web- Explore transformation and content sharing of Facebook.

SOCIAL NETWORK ANALYSIS : Development of Social Network Analysis- Historical perspective of SNA and its applications- sociology and marketing -Key Concepts and Measures in Network Analysis- metrics of centrality and closeness centrality- concept of weak ties - Electronic Sources for Network Analysis.

KNOWLEDGE REPRESENTATION ON THE SEMANTIC WEB : Ontology and Role of Semantic Web - frameworks of knowledge and retrieval information - Ontology-Based Knowledge Representation- improve machine understanding through ontologies structure data-Ontology Languages for the Semantic Web: RDF, OWL, and SPARQL.

MODELING AND AGGREGATING SOCIAL NETWORK DATA: State-of-the-Art in Network Data Representation - contemporary methods represent social relationships and interactions- Ontological Representation of Social Individuals and Relationships- social entities and attributes modeled - aggregating and Reasoning with Social Network Data- Techniques for synthesizing data.

SOCIAL-SEMANTIC APPLICATIONS AND DATA EXTRACTION: Generic Architecture for Social-Semantic Applications- Understanding frameworks - integrate social and semantic data- Tools and Technologies such as Apache Jena, Neo4j, and D3.js - Social Network Extraction- web scraping and API usage- Optimization, Prediction, and Evaluation- Explore machine learning methods for predictive analytics - evaluation of social media campaigns.

Reference Books & web resources

1. John G. Breslin, Alexandre Passant, Stefan Decker, “The Social Semantic Web”, Springer, 2009.(Chapters 1-8)
2. Yong Wang, Wei Fan, Zhiyong Lu, “Social Semantic Web: Technology and Applications”, 2010.
3. Simon Haykin, “Digital Communications”, John Wiley & Sons Pvt. Ltd,, 2001.
4. Dean Allemang & James Hendler, “Semantic Web Foundations: Semantic Web for the Working Ontologist”, 2011.
5. John G. Proakis, “Digital Communications” McGraw Hill International Edition, Fourth Edition, 2001.
6. Bernard Sklar, “Digital Communications: Fundamentals and Applications”, 2nd Edition, Prentice Hall, 2001.
7. John R Barry, Edward Lee and David G, Messerschmitt, “Digital Communication”, 3rd Edition, Springer, 2003.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO THE SEMANTIC WEB**	
1.1	Limitations of the Current Web	2
1.2	Development of the Semantic Web	2

Module No.	Topic	No. of Periods
1.3	Emergence of the Social Web	2
2	**SOCIAL NETWORK ANALYSIS**	
2.1	Development of Social Network Analysis	2
2.2	Key Concepts and Measures in Network Analysis	3
2.3	Electronic Sources for Network Analysis	2
3	**KNOWLEDGE REPRESENTATION ON THE SEMANTIC WEB**	
3.1	Ontology and Their Role in the Semantic Web	2
3.2	Ontology-Based Knowledge Representation	2
3.3	Ontology Languages for the Semantic Web (RDF and OWL)	2
4	**MODELLING AND AGGREGATING SOCIAL NETWORK DATA**	
4.1	State-of-the-Art in Network Data Representation	2
4.2	Ontological Representation of Social Individuals and Relationships	3
4.3	Aggregating Social Network Data	2
4.4	Reasoning with Social Network Data	2
5	**SOCIAL-SEMANTIC APPLICATIONS AND DATA EXTRACTION**	
5.1	Generic Architecture for Social-Semantic Applications	2
5.2	Tools and Technologies for Data Processing (Apache Jena, Neo4j, D3.js)	3
5.3	Social Network Extraction Techniques (Web Scraping and APIs)	2
	Total	**34**

Course Designer(s):

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23DSPN0 CLOUD COMPUTING

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This course offers a comprehensive exploration of virtualization and cloud computing concepts, focusing on the technologies and architectures that enable modern cloud services. Also focus on virtualization and hypervisors, delve into cloud architecture fundamentals, service models, and storage solutions, providing insights into the intricacies of cloud deployments and security considerations will be addressed in detail.

Prerequisite

- 23DS550 - Computer Networks

Course Outcomes

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

CO1	Understand the foundational concepts of virtualization, hypervisor types and roles	Understand
CO2	Implement the cloud architecture fundamentals, including service models and deployment strategies.	Apply
CO3	Integrate various cloud service models, including SaaS, PaaS, and IaaS, and their real-world applications.	Apply
CO4	Implement the security challenges	Apply
CO5	Utilize and implement deployment tools and techniques	Apply
CO6	Explore and analyse advanced cloud concepts and conduct case studies.	Analyse

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	S	M	L	L	M	-	M	-	-	L	L	M
CO2	S	S	S	M	M	M	M	-	S	-	-	L	M	L
CO3	M	S	S	S	S	M	M	-	M	-	-	M	L	M
CO4	M	M	S	S	M	M	S	-	M	-	-	S	L	L
CO5	S	M	S	S	S	S	M	-	S	-	-	M	S	S
CO6	M	S	S	M	S	M	M	-	S	-	-	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10																							10	10				
CO2	5	10	30						50																		10			
CO3	5	10	20							50																5	10			
CO4													10		10											5	10			
CO5														10	20						50						10			
CO6														10	20	20						50					10	20		
Total (in %)	100						100						100						100						100					

Syllabus

VIRTUALIZATION AND Hypervisors : Fundamental concepts of virtualization - significance of modern computing - types of virtualization - overview of hypervisors- architecture - functionalities of Type 1 (bare-metal) and Type 2 (hosted) hypervisors - various hypervisors (Xen, KVM, VMware, VirtualBox, and Hyper-V) - role of hypervisors - use cases- performance characteristics - management tools.

CLOUD ARCHITECTURE FUNDAMENTALS : Focusing on cloud architecture - core characteristics - service models of Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) - deployment models (public, private, hybrid, and community clouds) - essential cloud concepts and terminologies - load balancing – scalability – elasticity - deployment strategies - monitoring cloud environments - Service Level Agreements (SLAs) - billing practices in cloud computing.

CLOUD SERVICE MODELS AND STORAGE SOLUTIONS : SaaS segment - Open SaaS approach- PaaS evolution, benefits, and disadvantages - IaaS component - performance strategies - system redundancy- cloud-based NAS devices - Identity as a Service (IDaaS)- Database as a Service (DBaaS) - Monitoring as a Service (MaaS) - different cloud storage providers - cloud file systems - techniques MapReduce - Case studies : Amazon S3 and Walrus.

SECURITY AND DEPLOYMENT TOOLS IN CLOUD COMPUTING : critical aspects of security - identity and access management - data loss prevention - web security and security assessments - intrusion management, and encryption - business continuity and disaster recovery (BCDR) implementations - network security challenges in cloud environments - cloud deployment tools of Eucalyptus, Nimbus, OpenStack, CloudStack, and OpenNebula.

ADVANCED CLOUD CONCEPTS AND CASE STUDIES : Advanced cloud concepts - cloud operating systems - federated clouds - data center architectures tailored for cloud computing - principles of virtualization platforms - virtual machine migration, and load balancing techniques - scalability, performance, and quality of service (QoS) in cloud computing environments - alongside security and privacy issues - simulation tools like CloudSim.

Reference Books & Web Resources

1. Matthew Portnoy, “Virtualization Essentials”, 2016. (Chapter : 1,2,3,4)
2. Arshdeep Bahga and Vijay Madisetti, “Cloud Computing: A Hands-On Approach”, 2014.
3. Thomas Erl, **“**Cloud Computing: Concepts, Technology & Architecture”, 2013(Chapter 1,2,3)
4. Michael J. Kavis,” Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS)”, 2014.(Chapter 2,3,5,7,9)
5. https://onlinecourses.nptel.ac.in/noc21_cs14/preview,By Prof. Soumya Kanti Ghosh, IIT Kharagpur, NPTEL.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**VIRTUALIZATION AND HYPERVISORS**	
1.1	Introduction to Virtualization	1
1.2	Types of Virtualization	1
1.3	Overview of Hypervisors	1
1.4	In-depth Analysis of Hypervisors	2
1.5	Hypervisors in Cloud Computing	1
2	**CLOUD ARCHITECTURE FUNDAMENTALS**	
2.1	Introduction to Cloud Architecture	1
2.2	Service Models: IaaS, PaaS, SaaS	2
2.3	Deployment Models: Public, Private, Hybrid, and Community Clouds	2
2.4	Scalability, Elasticity, Load Balancing, and Monitoring in Cloud Environments	1
2.5	Software-Defined Networking (SDN) and Network Function Virtualization (NFV)	1
3	**CLOUD SERVICE MODELS AND STORAGE SOLUTIONS**	
3.1	SaaS: Multitenancy, Open SaaS Approach	2
3.2	PaaS: Evolution, Benefits, and Limitations	2
3.3	IaaS: Performance Strategies, System Redundancy, Cloud-based NAS	2
3.4	Identity as a Service (IDaaS), Database as a Service (DBaaS), Monitoring as a Service (MaaS)	2
3.5	Cloud File Systems and MapReduce	1
4	**SECURITY AND DEPLOYMENT TOOLS IN CLOUD COMPUTING**	
4.1	Security in Cloud: Identity Management, Data Loss Prevention	1
4.2	Encryption Techniques and Intrusion Management in Cloud Environments	1
4.3	Business Continuity and Disaster Recovery (BCDR) in Cloud Computing	1
4.4	Cloud Deployment Tools	1
5	**ADVANCED CLOUD CONCEPTS AND CASE STUDIES**	
5.1	Cloud Operating Systems, Federated Clouds	1
5.2	Data Centre Architectures for Cloud Computing	1
5.3	Virtual Machine Migration and Load Balancing Techniques	1

Module No.	Topic	No. of Periods
5.4	Scalability, Performance, and QoS in Cloud Computing	1
5.5	Case Studies: Amazon Web Services (AWS), Microsoft Azure, IBM Cloud	1
6	**SIMULATION TOOLS AND PRESENTATIONS**	
6.1	Introduction to CloudSim: Features and Use Cases	1
6.2	Practical Simulation with CloudSim	1
6.3	Group Presentations on Case Studies	1
	Total	**34**

Course Designer(s):

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23DSPP0	INTERNET OF THINGS AND DATA ANALYTICS	Category	L	T	P	Credit
		PEC	2	1	0	3

Preamble

This course provides an overview of the Internet of Things (IoT), covering key concepts, architectures, and applications. Students will explore data collection methods, analytics techniques, and the challenges of security and interoperability, preparing them to tackle real-world IoT problems.

Prerequisite

- 23DS130: Digital Electronics and Computer Organization
- 23DS470: Predictive Analytics Lab
- 23DS550: Computer Networks
- 23DS680: Big Database Systems Lab

Course Outcomes

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

CO1	Describe how IoT systems work and their real-world uses.	Understand
CO2	Analyze IoT data to get useful insights using different analytics methods.	Analyze
CO3	Apply NoSQL databases to store and manage IoT data.	Apply
CO4	Examine IoT solutions by evaluating sensor and device integration	Analyze
CO5	Use machine learning to analyze IoT data for predicting trends and spotting issues.	Analyze
CO6	Identify and solve security and privacy problems in IoT systems.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	S	-	-	-	-	M	-	L	S	M
CO2	S	S	L	S	M	-	-	-	-	-	-	-	S	M
CO3	S	M	S	M	S	-	L	-	-	-	-	-	S	M
CO4	S	S	S	S	S	S	M	L	S	M	L	M	S	M
CO5	S	S	S	S	M	-	-	-	-	-	-	L	S	M
CO6	S	M	S	M	L	S	L	S	-	M	-	L	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	20						25																	2	10				
CO2													10			20					25				2			20		
CO3	5	10	20						25																		10			
CO4	5	10		20						50															2			20		
CO5													10			20						50			2			20		
CO6													5	10	20						25				2		10			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO IOT (INTERNET OF THINGS): Definition and key concepts - IoT ecosystem - Applications - IoT Architecture (Layers of IoT, IoT Communication protocols) - IoT Challenges
(Security and data privacy, scalability, interoperability).

IOT HARDWARE AND DATA COLLECTION: IoT Devices and Sensors (Sensors, actuators and microcontrollers) - Data Collection Methods (Real-time data acquisition and streaming) - CaseStudy (smart agriculture and healthcare)

IOT DATA STORAGE AND MANAGEMENT: Introduction to NoSQL Databases (MongoDB, Cassandra, HBase) and their relevance for IoT - Data models for IoT (Key-Value, Document, Column-Family, Graph) - Storing and querying IoT data in NoSQL databases - Case Study (Using MongoDB for storing sensor data in a smart city or smart agriculture application)

IOT DATA ANALYTICS BASICS: Introduction to IoT Data Analytics and its important - Descriptive (Aggregation and visualization of IoT data) and Predictive Analytics (Predicting sensor failures) - Tools for IoT Analytics (Google BigQuery, Power BI) - Case Study (Predictive maintenance in industrial IoT using sensor data) - Security in IoT Data Analytics (security threats and anomalies).

EDGE AND FOG COMPUTING IN IOT: Edge vs. cloud-based data collection - Edge analytics vs. cloud analytics - Bringing analytics closer to IoT devices - Case Study (Smart grids and autonomous vehicles as real-world examples of edge/fog computing applications)

ADVANCED MACHINE LEARNING FOR IOT DATA: Introduction to time-series forecasting for IoT sensor data. - Applying ML algorithms (ARIMA, LSTM) to IoT datasets - Real-time data processing and prediction for IoT applications (anomaly detection in IoT networks)

Reference Books & web resources

1. Amit Kumar Tyagi (2022). “Internet of Things: Theory & Practice”. BPB Publications (Chapters: 1, 3, 11 & 14)
2. K.N. Raja Rao (2018). “Internet of Things: Concepts and Applications (An Indian Adaptation)”. Wiley (Chapter: 1, 2, 3, 4, 5 & 6)
3. Misra, S., Mukherjee, A., & Roy, A. (2021). “Introduction to IoT”. Cambridge University Press. (Chapter: 5, 10, 11, 12, 13, 14, 17, 16)
4. Bahga, A. (2014). “Internet of Things: A Hands-On Approach”.
5. Waher, P. (2015). “Learning internet of things”. Packt publishing.
6. Pethuru Raj & Anupama C. Raman. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases". CRC Press

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO IOT**	
1.1	Definition and Key Concepts	1
1.2	IoT Ecosystem and Applications	1
1.3	IoT Architecture (Layers of IoT, IoT Communication Protocols)	2
1.4	IoT Challenges (Security and data privacy, scalability, interoperability)	1

Module No.	Topic	No. of Periods
2	**IOT HARDWARE AND DATA COLLECTION**	
2.1	IoT Devices and Sensors (Sensors, Actuators, Microcontrollers)	2
2.2	Data Collection Methods (Real-time data acquisition and streaming)	2
2.3	Case Study (Smart agriculture and healthcare)	2
3	**IOT DATA STORAGE AND MANAGEMENT**	
3.1	Introduction to NoSQL Databases (MongoDB, Cassendra, HBase)	2
3.2	Data Models for IoT (Key-Value, Document, Column-Family, Graph)	2
3.3	Storing and Querying IoT Data in NoSQL Databases	1
3.4	Case Study (Using MongoDB for storing sensor data in a smart city or smart agriculture application)	2
4	**IOT DATA ANALYTICS BASICS**	
4.1	Introduction to IoT Data Analytics and Its Importance	1
4.2	Descriptive Analytics (Aggregation and Visualization of IoT Data)	1
4.3	Predictive Analytics (Predicting Sensor Failures)	1
4.4	Tools for IoT Analytics (Google BigQuery, Power BI)	2
4.5	Case Study (Predictive maintenance in industrial IoT using sensor data)	1
5	**EDGE AND FOG COMPUTING IN IOT**	
5.1	Edge vs. Cloud-based Data Collection	1
5.2	Edge Analytics vs. Cloud Analytics	1
5.3	Bringing Analytics Closer to IoT Devices	1
5.4	Case Study (Smart grids and autonomous vehicles)	2
6	**ADVANCED MACHINE LEARNING FOR IOT DATA**	
6.1	Introduction to Time-Series Forecasting for IoT Sensor Data	1
6.2	Applying ML Algorithms (ARIMA, LSTM) to IoT Datasets	2
6.3	Real-Time Data Processing and Prediction for IoT Applications (Anomaly detection in IoT networks)	2
	Total	**34**

Course Designer:

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23DSPQ0 COMPUTATIONAL FINANCE

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This Computational Finance course teaches current C++ programming and financial modeling. Parallel computing, Monte Carlo simulations, and adjoint differentiation. Students learn how to create high-performance financial simulations for data-driven finance jobs.

Prerequisite

- 23DS510 : Numerical Methods
- 23DS520 : Optimization Techniques

Course Outcomes

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

CO1	Explain the modern C++ programming concepts for effective financial modeling.	Understand
CO2	Implement parallel computing techniques to enhance the performance of financial algorithms and simulations.	Apply
CO3	Use Monte Carlo simulations for asset pricing and risk assessment in financial applications.	Apply
CO4	Illustrate adjoint differentiation methods for optimizing financial models and calculating sensitivities.	Apply
CO5	Implement the serial and parallel financial simulations using efficient coding practices.	Apply
CO6	Examine the memory management using data structures for algorithmic adjoint differentiation in financial contexts.	Analyze

Mapping with Programme Outcomes

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

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	-	S	-	-	-	-	-	M	S	M	S	S
CO2	S	S	M	S	S	-	-	-	-	M	S	S	S	S
CO3	S	S	S	M	S	S	-	-	-	S	S	-	S	M
CO4	-	S	M	S	-	-	S	M	-	-	-	S	S	M
CO5	M	S	M	-	S	S	-	M	-	S	M	-	S	S
CO6	-	M	M	-	M	M	-	S	-	M	-	M	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	10						20																	10	10				
CO2	10	10	20						40																	10	10			
CO3		10	30						40																		20			
CO4													10	10	10						20						10			
CO5													10	10	30						40					10	10			
CO6																20						40						10		
Total (in %)	100						100						100						100						100					

Syllabus

MODERN C++ CONCEPTS FOR COMPUTATIONAL FINANCE: Lambda Expressions - Functional Programming - Move Semantics, Smart Pointers.

INTRODUCTION TO PARALLEL C++ FOR FINANCIAL APPLICATIONS: Multi-threading - Thread Management - Data Sharing - Thread Local Storage – Locks – Deadlocks – RAII - Condition Variables - Task Management.

MONTE CARLO SIMULATIONS FOR ASSET PRICING: Asset Pricing Models - Monte Carlo Methods - Random Number Generation - Randomness Quality Improvement.

SERIAL AND PARALLEL IMPLEMENTATION OF FINANCIAL SIMULATIONS: Simulation Algorithms - Serial Implementation - Parallel Implementation - Skip Ahead Techniques.

INTRODUCTION TO ADJOINT DIFFERENTIATION FOR FINANCIAL MODELS: Adjoint Differentiation - Calculation Graphs - Directed Acyclic Graphs - Adjoint Mathematics - Sensitivities.

ALGORITHMIC ADJOINT DIFFERENTIATION AND EXPRESSION TEMPLATES: Algorithmic Differentiation - Memory Management - Expression Templates - Templated Code.

Reference Books

1. Antoine Savine, “Modern Computational Finance: AAD and Parallel Simulations”, Hardcover – Illustrated, 7 December 2018.
2. Argimiro Arratia, “Computational Finance: An Introductory Course with R: 1 (Atlantis Studies in Computational Finance and Financial Engineering)”, Hardcover – Abridged, 20 May 2014.
3. Omur Ugur, “Introduction to Computational Finance”, An: 1 (Series in Quantitative Finance), Hardcover, 29 December 2008, ISBN 978-1848161924, Publisher: Imperial College Press.
4. T. D. M. H. C. N. P. A. P. A., “Quantitative Methods in Derivatives Pricing - An Introduction to Computational Finance”: 124 (Wiley Finance), Hardcover, 16 May 2002, ISBN 978-0471394471, Publisher: John Wiley & Sons Inc.
5. C. M. F. L., “Computational Methods for Quantitative Finance: Finite Element Methods for Derivative Pricing (Springer Finance)”, Hardcover, March 6, 2015, ISBN 978-3642435324, Publisher: Springer.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**MODERN C++ CONCEPTS**	
1.1	Lambda Expressions	2
1.2	Functional Programming	2
1.3	Move Semantics	2
1.4	Smart Pointers	2
2	**PARALLEL PROGRAMMING IN C++**	
2.1	Introduction to Multithreading	2
2.2	Thread Management	2
2.3	Data Synchronization	1

2.4	Deadlock Prevention	1
2.5	Task Management	2
3	**MONTE CARLO METHODS IN FINANCE**	
3.1	Asset Pricing Models	2
3.2	Monte Carlo Simulation Techniques	1
3.3	Random Number Generation	1
3.4	Variance Reduction Techniques	1
4	**IMPLEMENTATION OF FINANCIAL SIMULATIONS**	
4.1	Serial vs. Parallel Algorithms	2
4.2	Monte Carlo Simulation Implementation	2
4.3	Skip-Ahead Techniques	2
5	**ADJOINT DIFFERENTIATION**	
5.1	Overview of Adjoint Differentiation	2
5.2	Gradient Calculation with AD	1
5.3	Adjoint Methods for Pricing Models	2
6	**ALGORITHMIC DIFFERENTIATION TECHNIQUES**	
6.1	Efficient AAD Implementation	1
6.2	Expression Templates	1
6.3	Case Studies in Financial Applications	2
	Total	**36**

Course Designer(s):

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23DSPR0	ENTERPRISE INFORMATION SYSTEMS	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course aims to enable the students to make or influence decisions related to the selection, design and support of Enterprise Information Systems.

Prerequisite

- NIL

Course Outcomes

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

CO1	Explain the design, construction and management of relational database systems.	Understand
CO2	Describe the strengths and weakness of different approaches to data management.	Understand
CO3	Apply knowledge of processes, tools and techniques involved in information management within an enterprise.	Apply
CO4	Compare and contrast the range of database technologies and methods of database construction.	Apply
CO5	Apply the knowledge of database-driven systems within a business context.	Apply
CO6	Analyze the information and data technologies in the context of organizational needs.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	M	M	M	-	-	-	-	-	-	-	L	M
CO2	M	M	M	M	M	-	-	-	-	-	-	-	M	M
CO3	M	S	S	S	M	M	M	L	M	M	-	-	M	S
CO4	M	M	S	M	M	L	-	-	-	M	M	M	M	S
CO5	M	S	S	S	M	L	-	-	-	S	S	S	M	S
CO6	S	S	S	M	M	M	M	M	M	M	M	M	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10																							4	6				
CO2	10	10																							4	6				
CO3	10	10	20						50					10											4	6	10			
CO4													10	10	20						40				4	6	10			
CO5													10	10	20						40				4	6	10			
CO6			10	10						50				10								20					10	10		
Total (in %)	100						100						100						100						100					

Syllabus

ORGANIZATIONS, MANAGEMENT, AND THE NETWORKED ENTERPRISE: the role of information systems in Business today, Perspectives on Information Systems, contemporary approaches to information systems.

INFORMATION SYSTEMS, ORGANIZATIONS, AND STRATEGY: organizations and information systems, information systems impact organizations and business firms, using information systems to achieve competitive advantage, using systems for competitive advantage: management issues.

IT INFRASTRUCTURE AND EMERGING TECHNOLOGIES: IT infrastructure, infrastructure components, contemporary hardware platform trends, contemporary software platform trends.

MANAGING KNOWLEDGE: the knowledge management landscape, enterprise-wide knowledge management systems, knowledge work systems.

ENHANCING DECISION MAKING: decision making and information systems, business intelligence in the enterprise, business intelligence constituencies.

BUILDING INFORMATION SYSTEMS: Systems as planned organizational change, overview of systems development systems, alternative systems-building approaches, application development for the digital firm.

MANAGING GLOBAL SYSTEMS: the growth of international information systems, organizing international information systems.

Reference Books & web resources

1. Kenneth C. Laudon Jone & P. Laudon, “Management Information Systems”, Thirteenth Edition, Pearson Education Limited 2014.
2. Terry Lucey, “Management Information System”, Ninth Edition, 2005, Thompson.
3. Effy Oz, “Management Information System”, Fourth International Student Edition, Thomson, 6th Edition, 2008.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**ORGANIZATIONS, MANAGEMENT, AND THE NETWORKED ENTERPRISE**	
1.1	The role of information systems in Business today	1
1.2	Perspectives on Information Systems, contemporary approaches to information systems.	2
2	**INFORMATION SYSTEMS, ORGANIZATIONS, AND STRATEGY**	
2.1	Organizations and information systems,	1
2.2	Information systems impact organizations and business firms,	2
2.3	Using information systems to achieve competitive advantage,	1
2.4	Using systems for competitive advantage: management issues.	1
3	**IT INFRASTRUCTURE AND EMERGING TECHNOLOGIES**	
3.1	IT infrastructure, infrastructure components,	1
3.2	Contemporary hardware platform trends & contemporary software platform trends.	1

3.3	Managing Knowledge	2
3.4	The knowledge management landscape,	1
3.5	Enterprise-wide knowledge management systems,	2
3.6	Knowledge work systems.	2
4	**ENHANCING DECISION MAKING**	
4.1	Decision making and information systems,	2
4.2	Business intelligence in the enterprise,	2
4.3	Business intelligence constituencies.	2
5	**BUILDING INFORMATION SYSTEMS**	
5.1	Systems as planned organizational change,	2
5.2	Overview of systems development systems,	2
5.3	Alternative systems-building approaches,	2
5.4	Application development for the digital firm.	2
6	**MANAGING GLOBAL SYSTEMS**	
6.1	The growth of international information systems,	2
6.2	Organizing international information systems.	1
	Total	**34**

Course Designer(s):

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		Category	L	T	P	Credit
23DSPS0	**RANDOMIZED ALGORITHMS**	PEC	3	0	0	3

Preamble

This course aims to introduce students to randomized algorithms, focusing on their design, classification, and application in optimization problems. Students will develop and analyze efficient algorithms utilizing randomness to solve real-world challenges.

Prerequisite

- 23DS430 - Design and Analysis of Algorithms
- 23DS510 -Numerical Methods
- 23DS520 - Optimization Techniques

Course Outcomes

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

CO1	Design randomized algorithms for effectively solving optimization problems.	Apply
CO2	Implement key design paradigms for randomized algorithms.	Apply
CO3	Formulate representative randomized algorithms.	Apply
CO4	Apply randomized and approximation algorithms to combinatorial optimization.	Apply
CO5	Implement LP-based and semi-definite programming methods for optimization.	Apply
CO6	Utilize practical skills through the implementation of randomized algorithms.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	L	-	-	-	-	L	L	-	L	S	M
CO2	S	S	S	L	-	-	-	-	-	-	-	-	S	M
CO3	S	S	S	L	-	-	-	-	L	L	-	L	S	M
CO4	S	S	S	L	-	-	-	-	-	-	-	-	S	M
CO5	S	S	S	L	-	-	-	-	-	-	-	-	S	M
CO6	S	S	S	L	-	-	-	-	L	L	-	L	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	5	10	20						25																2	5	15			
CO2	5	10	10						25																2		10			
CO3	5	10	25						50																2	5	15			
CO4													5	10	20						25				2		10			
CO5													5	10	10						25				2		10			
CO6													5	10	25						50					5	15			
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO RANDOMIZED ALGORITHMS: Review on Algebra, Number Theory, Combinatorics, and Probability Theory - Randomness as a Source of Efficiency - Designing a Communication Protocol - Models of Randomized Algorithms - Classification: Las Vegas and Monte Carlo (one-sided error, bounded-error, unbounded-error) - Classification of Randomized Algorithms for Optimization Problems.

DESIGN PARADIGMS: Foiling the Adversary - Abundance of Witnesses - Fingerprinting - Random Sampling - Amplification - Random Rounding.

REPRESENTATIVE ALGORITHMS: Foiling the Adversary - Universal Hashing - Fingerprinting in Communication Protocols - Verification of Matrix Multiplication - Equivalence of Two Polynomials - Success Amplification and Random Sampling - Min-Cut, Satisfiability, and Repeated Random Sampling - Abundance of Witnesses - Optimization & Random Rounding - Primality Testing - Max-SAT Review - Hybrid Sampling & Rounding - Derandomization Techniques.

INTRODUCTION TO APPROXIMATION ALGORITHMS: Review on Complexity Theory - Performance Ratios for Approximation Algorithms - Cardinality Vertex-Cover Problem - Well-characterized Problems and Min-Max Relations - Travelling Salesperson Problem (TSP).

COMBINATORIAL ALGORITHMS: Set Cover - Steiner Tree - Multi-way Cut and k-Cut - Bin Packing.

LP-BASED ALGORITHMS: LP-Duality - Set Cover via Dual Fitting - Set Cover via Primal-Dual Schema - Rounding Applied to Set Cover - Multi-way Cut - Semi-Definite Programming - Randomized Rounding Algorithm - Guarantee Improvement for MAX2SAT.

PRACTICAL EXERCISES: Implementation of Randomized Quick Sort - Finding Solutions for S-T Min-Cut Problem - Implementation of Randomized Selection - Implementation of Treap Data Structure - Problems Using Randomized Hash Table - Implementation of Shortest Path and Fast Min-Cut Algorithms - Implementation of Randomized Primality Testing - Implementing the K-Server Online Algorithms.

Reference Books

1. Rajeev Motwani and Prabhakar Raghavan, “Randomized Algorithms”, Cambridge University Press, 1995 (Updated online edition in 2013).
2. Vijay V. Vazirani – “Approximation Algorithms”, Springer Science & Business Media, 2013.
3. JurajHromkovic– “Design and Analysis of Randomized Algorithms”, First edition, Springer, 2005.
4. David P. Williamson and David B. Shmoys, “The Design of Approximation Algorithms”, Cambridge University Press, 2011.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO RANDOMIZED ALGORITHMS**	
1.1	Review of Algebra, Number Theory, Combinatorics, and Probability Theory	1
1.2	Randomness as a Source of Efficiency	1
1.3	Designing a Communication Protocol and Models of	1

Module No.	Topic	No. of Periods
	Randomized Algorithms	
1.4	Classification: Las Vegas and Monte Carlo (one-sided error, bounded-error, unbounded-error)	1
1.5	Classification of Randomized Algorithms for Optimization Problems	1
2	**DESIGN PARADIGMS**	
2.1	Foiling the Adversary	1
2.2	Abundance of Witnesses	1
2.3	Fingerprinting	1
2.4	Random Sampling	1
2.5	Amplification	1
2.6	Random Rounding	1
3	**REPRESENTATIVE ALGORITHMS**	
3.1	Foiling the Adversary, Universal Hashing	1
3.2	Fingerprinting in Communication Protocols, Verification of Matrix Multiplication	1
3.3	Equivalence of Two Polynomials, Success Amplification and Random Sampling	1
3.4	Min-Cut, Satisfiability, and Repeated Random Sampling	1
3.5	Abundance of Witnesses - Optimization & Random Rounding	1
3.6	Primality Testing - Max-SAT Review	1
3.7	Hybrid Sampling & Rounding - Derandomization Techniques.	1
4	**INTRODUCTION TO APPROXIMATION ALGORITHMS**	
4.1	Review on Complexity Theory, Performance Ratios for Approximation Algorithms	1
4.2	Cardinality Vertex-Cover Problem	1
4.3	Well-characterized Problems and Min-Max Relations	1
4.4	Travelling Salesperson Problem (TSP)	1
5	**COMBINATORIAL ALGORITHMS**	
5.1	Set Cover	1
5.2	Steiner Tree	1
5.3	Multi-way Cut and k-Cut	1
5.4	Bin Packing	1

Module No.	Topic	No. of Periods
6	**LP-BASED ALGORITHMS**	
6.1	LP-Duality - Set Cover via Dual Fitting	1
6.2	Set Cover via Primal-Dual Schema - Rounding Applied to Set Cover	1
6.3	Multi-way Cut - Semi-Definite Programming	1
6.4	Randomized Rounding Algorithm - Guarantee Improvement for MAX2SAT.	1
7	**PRACTICAL EXERCISES**	
7.1	Implementation of Randomized Quick Sort - Finding Solutions for S-T Min-Cut Problem	1
7.2	Implementation of Randomized Selection - Implementation of Treap Data Structure.	1
7.3	Problems Using Randomized Hash Table - Implementation of Shortest Path and Fast Min-Cut Algorithms.	1
7.4	Implementation of Randomized Primality Testing - Implementing the K-Server Online Algorithms	1
	Total	**34**

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23DSPT0 PRINCIPLES OF MANAGEMENT

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

This course aims to enable students to understand management principles, processes and procedures in consideration of their effort on individual actions.

Prerequisite

- Nil

Course Outcomes

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

CO1	Explain the fundamental concepts and principles of management.	Understand
CO2	Apply theories to improve the practice of management.	Apply
CO3	Demonstrate the key competencies needed to be an effective manager.	Apply
CO4	Apply managerial ethics and social responsibility in decision-making and organizational practices.	Apply
CO5	Apply an understanding of the complexities in real-life organizations and management situations.	Apply
CO6	Demonstrate critical thinking when presented with managerial issues and problems.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	M	M	L	-	-	-	-	-	-	-	-	-
CO2	M	M	M	M	L	-	-	-	-	-	-	-	-	-
CO3	M	M	M	M	M	L	-	M	-	M	S	S	L	S
CO4	M	M	L	M	M	L	L	M	-	M	S	S	L	S
CO5	S	M	S	S	S	L	L	M	S	M	S	S	L	S
CO6	S	S	S	S	S	S	L	S	S	M	S	S	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	5																							4	6				
CO2	5	15	20																						4	6	10			
CO3	5	15	20																						4	6	10			
CO4			10						50				5	10	15						30				4		10			
CO5									50				5	15	15						40				4	6	10			
CO6													5	15	15						30					6	10			
Total (in %)	100						100						100						100						100					

Syllabus

PRINCIPLES OF MANAGEMENT: Meaning, Definition and Significance of Management, Basic Functions of Management – Planning, Organizing, Staffing, Directing and Controlling. Organizational Environment – Social, Economic, Technological and Political. Corporate Social Responsibility - Case discussion.

INDUSTRIAL AND BUSINESS ORGANIZATION: Growth of Industries (Small Scale, Medium Scale and Large Scale Industries). Forms of Business Organizations. Resource Management – Internal and External Sources.

GROUP BEHAVIOUR: Group dynamics, Group formation and development, group structure and group cohesiveness. Informal organization – Sociometry – Interaction analysis

GLOBALISATION: Issues for global competitiveness, proactive and reactive forces of globalization. Cross cultural management – Management of work force diversity.

HUMAN RESOURCE MANAGEMENT: Objectives and Functions, Selection and Placement, Training and Development – Conflict management – Stress management - Human resource management in global environment - Human resource information system(HRIS) - Case discussion.

Reference Books & web resources

1. Harold Koontz, Heinz Weihrich and Ramachandra Aryasri, “Essentials of Management”, Tata McGraw Hill, 11th Edition.
2. Ramachandra Aryasri, Harold Koontz and Heinz Weihrich, “Principles of Management” Tata McGraw Hill, 2016, 2nd Edition.
3. Mamoria C B and S.V.Gankar, “Personnel Management”, 2011.
4. John R Barry, Edward Lee and David G. Messerschmitt, “Digital Communication”, 3rd Edition. Springer, 2003.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**PRINCIPLES OF MANAGEMENT**	
1.1	Meaning, Definition and Significance of Management,	2
1.2	Basic Functions of Management – Planning, Organizing, Staffing, Directing and Controlling.	2
1.3	Organizational Environment – Social, Economic, Technological and Political.	2
1.4	Corporate Social Responsibility - Case discussion.	2
2	**INDUSTRIAL AND BUSINESS ORGANIZATION**:	
2.1	Growth of Industries (Small Scale, Medium Scale and Large Scale Industries).	3
2.2	Forms of Business Organizations.	2
2.3	Resource Management – Internal and External Sources.	2
3	**GROUP BEHAVIOUR**	

3.1	Group dynamics, Group formation and development, group structure and group cohesiveness.	2
3.2	Informal organization – Sociometry – Interaction analysis	3
4	**GLOBALISATION**	
4.1	Issues for global competitiveness, proactive and reactive forces of globalization.	2
4.2	Cross cultural management – Management of work force diversity.	2
5	**HUMAN RESOURCE MANAGEMENT**	
5.1	Objectives and Functions, Selection and Placement, Training and Development	2
5.2	Conflict management	2
5.3	Stress management	2
5.4	Human resource management in global environment	2
5.5	Human resource information system(HRIS) - Case discussion.	2
	Total	**34**

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23DSPU0	ACCOUNTING AND FINANCIAL MANAGEMENT	Category	L	T	P	Credit
		PEC	3	0	0	3

Preamble

This course aims in introducing concepts of accounting and enables an engineer in taking useful financial and costing related decisions by providing scientific tools and techniques.

Prerequisite

- NIL

Course Outcomes

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

CO1	Explain the basic concepts and process of accounting and finance.	Understand
CO2	Develop trail balance and financial statements like Trading, Profit and Loss accounts, Balance sheet and Cost sheet.	Apply
CO3	Demonstrate the concepts and operations of budgetary control.	Understand
CO4	Apply techniques like break event analysis and budgeting for an organization.	Apply
CO5	Select the right sources of finance and mobilize the right quantum of finance and make use of them in most profitable investment avenues.	Apply
CO6	Apply the concepts if accounting in the real time applications.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	M	M	L	-	-	-	-	-	-	-	L	M
CO2	L	L	M	M	L	-	-	-	-	-	-	-	L	M
CO3	M	M	M	M	L	-	-	-	-	-	-	-	M	M
CO4	M	M	L	M	L	L	L	L	L	L	L	L	M	S
CO5	S	S	M	M	L	L	L	L	L	M	M	M	S	S
CO6	S	S	S	M	L	L	L	L	L	L	L	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	5	15																							4	6				
CO2	5	15	20						50																4	6	10			
CO3	5	15																							4	6				
CO4			20						50				5	10											4	6	10			
CO5													10	10	20						50				4	6	10			
CO6													5	20	20						50				4	6	10			
Total (in %)	100						100						100						100						100					

Syllabus

Accounting - Accounting process and principles, financial, cost and management accounting. Elements of book keeping, Journal, cash and handbook, Book reconciliation statement, Ledger, trial balance, profit and loss accounts, final accounts of proprietary and partnership concern and balance sheet.

Cost accounting – Objectives, elements of cost, understanding of the different methods of costing.

Financial Management – Meaning, scope and role, a brief study of functional areas of financial management. Introduction to various FM tools: Ration Analysis - Meaning - Basis of comparison - Types of ratios

Working Capital Management - Theory of Working Capital Management, Introduction, Nature of Working Capital, Concepts and Definitions of Working Capital, Need for Working Capital, Permanent and Temporary Working Capital, Changes in Working Capital, Determinants of Working Capital.

Budgeting – budgets, purpose, budgetary control, preparation of budgets, master budget, fixed and flexible budgeting.

Reference Books

1. M.C.Sukhla, T.S.Grewal, — ”Advanced Accounts” Vol Ill, S.Chand and Publications, New Delhi, 2012
2. Prasanna Chandra, — “Fundamentals of Financial Management”, Tata McGraw Hill, 2012.
3. Pandey, —”Financial Management”, Vikas Publishing House Pvt. Ltd., 2010
4. Choudhari, Chopde, “Book Keeping and Accountancy”
5. Choudhari, Chopde, “Cost Accounting”
6. M.Y.Khan, P.K. Jain, “Financial Management: Text and Problems”
7. Prasanna Chandra, “Financial Management Theory & Practice”, Tata McGraw Hill.
8. Siddiqui S.A. Siddiqui A.S. New Age, “Managerial Economics & Financial Analysis”

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**ACCOUNTING**	
1.1	Accounting process and principles, financial, cost and management accounting	2
1.2	Elements of book keeping, Journal, cash and handbook,	2
1.3	Book reconciliation statement, Ledger,	2
1.4	trial balance, profit and loss accounts,	3
1.5	final accounts of proprietary and partnership concern and balance sheet.	3
2	**COST ACCOUNTING**	
2.1	Objectives, elements of cost, understanding of the different methods of costing.	2
3	**FINANCIAL MANAGEMENT**	

3.1	Meaning, scope and role, a brief study of functional areas of financial management.	2
4	**INTRODUCTION TO VARIOUS FM TOOLS**	
4.1	Ration Analysis - Meaning - Basis of comparison - Types of ratios	2
5	**WORKING CAPITAL MANAGEMENT**	
5.1	Theory of Working Capital Management- Introduction, Nature of Working Capital, Concepts and Definitions of Working Capital	3
5.2	Need for Working Capital, Permanent and Temporary Working Capital,	3
5.3	Changes in Working Capital, Determinants of Working Capital.	3
6	**BUDGETING**	
6.1	Budgets, purpose, budgetary control	2
6.2	Preparation of budgets, master budget	3
6.3	Fixed and flexible budgeting.	3
	Total	**35**

Course Designer(s):

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		Category	L	T	P	Credit
23DSPV0	**WIRELESS NETWORK**	PEC	3	0	0	3

Preamble

This course explores the fundamental principles and emerging technologies in wireless communication networks, including protocols, architectures, and standards. It equips students with the skills to analyze, apply, and innovate within the rapidly evolving landscape of wireless networks and mobile communications.

Prerequisite

- 23DS550: Computer Networks

Course Outcomes

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

CO1	Explain the fundamental concepts of wireless communication, cellular networks, wireless LANs, spectrum allocation, and multiple access methods.	Understand
CO2	Describe the architecture and standards of wireless networks, security protocols, QoS, and related wireless technologies	Understand
CO3	Apply routing protocols in ad hoc and wireless sensor networks, and handle data aggregation, synchronization.	Apply
CO4	Apply mobile network and transport layer protocols to optimize communication in wireless and 2.5/3G networks.	Apply
CO5	Apply physical and MAC layer protocols of Wireless PANs and MANs, to address deployment issues.	Apply
CO6	Apply emerging WLAN technologies, cellular network advancements, and standards to implement solutions for RFID with IoT, M2M communications, and cloud-based services.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	S	L	S	S	M	-	-	-	M	-	-	L	M
CO2	M	S	M	S	M	-	-	-	-	M	-	-	L	M
CO3	L	S	L	S	S	-	-	-	-	-	-	-	M	S
CO4	M	S	L	S	S	-	-	-	-	-	-	-	L	M
CO5	L	L	S	S	S	-	-	-	-	-	-	-	L	M
CO6	M	S	L	S	S	M	-		-	-	-	-	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's Level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	10						25																	3	10				
CO2	10	15						25																	3	10				
CO3	10	15	30						50																3		15			
CO4													5	10	10						30				3		15			
CO5													5	10	20						40				3		15			
CO6													10	10	20						30					5	15			
Total (in %)	100						100						100						100						100					

Syllabus

WIRELESS FUNDAMENTALS: Introduction to cellular networks,-wireless local area networks- Spectrum allocations – Radio propagation models-Narrowband digital modulation and wireless fading environments. – Modern Communications Systems – MAC:SDMA – TDMA – FDMA - CDMA

WLAN TECHNOLOGIES: wireless network architectures – 802.11 Physical (PHY) layers – 802.11 MAC – Security Protocols: WPA WPA2, WPA3, IEEE 802.11i, Quality of Service (QoS): MAC enhancements: IEEE 802.11e– Related Wireless Standards (Hyperlan, HomeRF, Bluetooth, Zigbee, Wireless USB)- WiFi (IEEE 802.11x) and WiMAX (IEEE 802.16x) Standards

AD HOC AND SENSOR NETWORKS: Ad hoc Network- Characteristics- Table-driven (Proactive) and Source-initiated On Demand routing protocols (Reactive), Hybrid protocols - Routing in intermittently connected mobile networks. **Wireless Sensor networks**- Classification, MAC and Routing Protocols, Data Aggregation and Synchronization.

MOBILE NETWORK AND TRANSPORT LAYERS: Mobile IP – Dynamic Host Configuration Protocol-Mobile Ad Hoc Routing Protocols (AODV,DSR, OLSR)–Multicast routing protocols in wireless networks -TCP over Wireless Networks – Indirect TCP – Snooping TCP – MobileTCP – Transaction Oriented TCP- TCP over 2.5 / 3G wireless Networks.

WIRELESS PANs, MANs – Physical and MAC layer details, Wireless PANs – Architecture of Bluetooth Systems, Physical and MAC layer details, Standards- WLAN deployment issues- Interference – Resource Allocation, Wireless MANs (WiMAX, IEEE 802.16) architecture and standards

FUTURE TRENDS: Emerging WLAN Related Technologies – (IEEE 802.11ac, 802.11ax) Trends – Cellular network evolution– IEEE 802.20 (Mobile Broadband Wireless Access), IEEE 802.22 (Wireless Regional Area Networks), UWB, Cognitive Radio Networks, RFID – Convergence of 4G/5G with IoT, M2M communications, and cloud-based services

Reference Books& web resource

1. Gary. S. Rogers and John Edwards, “An Introduction to Wireless Technology”, Pearson Education, 2012.
2. SivaRam Murthy C and B.S Manoj, “Ad hoc Wireless Networks Architecture and Protocols”, Pearson Education, 2005.
3. KavehPahlavan, Prashant K. Krishnamurthy, “Principles of wireless networks : A unified approach”, John Wiley & Sons, 2011.
4. William Stallings, “Wireless Communication and Networks”, Pearson Education, 2009.
5. Dharma Prakash Agrawal and Qing-An Zeng, “Introduction to Wireless and Mobile Systems”, Thomson Press, 2007.
6. “Ad Hoc Networks: Fundamental Properties and Network Topologies" by Junshan Zhang (2021)
7. "Wireless Communications" by Andreas F. Molisch (3rd Edition, 2022)
8. **NPTEL Course**: Introduction to Wireless and Cellular Communications https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-cs37/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**WIRELESS FUNDAMENTALS**	

Module No.	Topic	No. of Periods
1.1	Introduction to cellular networks	1
1.2	wireless local area networks- Spectrum allocations	1
1.3	Radio propagation models	1
1.4	Narrowband digital modulation and wireless fading environments	1
1.5	Modern Communications Systems – Introduction to MAC	1
1.6	SDMA – TDMA -FDMA - CDMA	2
1.7	Cellular and Ad-hoc-Concepts.	1
2	**WLAN TECHNOLOGIES**	
2.1	wireless network architectures	1
2.2	802.11 Physical (PHY) layers – 802.11 MAC	1
2.3	Security Protocols: WPA WPA2, WPA3, IEEE 802.11i,	1
2.4	Quality of Service (QoS): MAC enhancements: IEEE 802.11e– Related Wireless Standards	1
2.5	WiFi (IEEE 802.11x) and WiMAX (IEEE 802.16x) Standards	1
3	**AD HOC AND SENSOR NETWORKS**	
3.1	Ad hoc Network- Characteristics- Table-driven (Proactive, Reactive routing protocols)	1
3.2	Hybrid protocols - Routing in intermittently connected mobile networks.	1
3.3	Wireless Sensor networks- Classification, MAC and Routing Protocols,	1
3.4	Data Aggregation and Synchronization.	1
4	**MOBILE NETWORK AND TRANSPORT LAYERS**:	
4.1	Mobile IP – Dynamic Host Configuration Protocol-	1
4.2	Mobile Ad Hoc Routing Protocols (AODV,DSR, OLSR)	1
4.3	TCP over Wireless Networks	1
4.4	Indirect TCP – Snooping TCP – MobileTCP	1
4.5	Fast Retransmit / Fast Recovery	1
4.6	Transmission/Timeout Freezing	1
4.7	Selective Retransmission	1
4.8	TCP over 2.5 / 3G wireless Networks.	1
5	**WIRELESS PANs MANs**	
5.1	Physical and MAC layer details	1

Module No.	Topic	No. of Periods
5.2	Wireless PANs	1
5.3	Architecture of Bluetooth Systems	1
5.4	Physical and MAC layer details, Standards	1
5.5	WLAN deployment issues	1
5.6	Interference – Resource Allocation,	1
5.7	Wireless MANs (WiMAX, IEEE 802.16) architecture and standards	1
6	**FUTURE TRENDS**	
6.1	Emerging WLAN Related Technologies – (IEEE 802.11ac, 802.11ax) Trends	1
6.2	Cellular network evolution (LTE, LTE-Advanced, 5G, 6G)	1
6.3	IEEE 802.20 (Mobile Broadband Wireless Access), IEEE 802.22 (Wireless Regional Area Networks),	1
6.4	UWB, Cognitive Radio Networks, RFID, Convergence of 4G/5G with IoT	1
	Total	**36**

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		Category	L	T	P	Credit
23DSPW0	**NETWORKSCIENCE**	PEC	3	0	0	3

Preamble

This course explores the identification, construction, visualization, and analysis of networks using mathematical and algorithmic approaches. Students will gain the ability to explain key concepts and results in network science both mathematically and conceptually.

Prerequisite

- 23DS220: Applied Statistics
- 23DS230 Graph Theory
- 23DS550: Computer Networks

Course Outcomes

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

CO1	Explain the fundamental concepts of graph theory, including networks, random networks , degree distributions, and clustering coefficients.	Understand
CO2	Describe the concepts of random and scale-free networks, including degree distribution, network evolution, and the role of hubs	Understand
CO3	Apply the Barabási-Albert model to simulate network growth through preferential attachment,	Apply
CO4	Examine the usage of Bianconi-Barabási model and bose-einstein condensation in network working	Apply
CO5	Apply methods for measuring degree correlations, such as assortativity and disassortativity, to identify patterns in real-world networks.	Apply
CO6	Analyze the robustness and vulnerability of networks using percolation theory, identifying critical nodes and links in a network.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	S	M	L	-	L	-	-	-	-	L	S	M
CO2	S	S	S	M	L	-	L	-	-	-	-	L	S	M
CO3	S	S	S	S	L	-	M	-	-	-	-	L	S	S
CO4	S	S	S	S	L	-	M	-	-	-	-	L	S	S
CO5	S	S	S	S	L	-	M	-	-	-	-	L	S	S
CO6	S	S	S	M	L	-	M	-	-	-	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						Assignment 1						CAT2						Assignment2						Terminal					
Bloom's Level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	10	15						25																	3	10				
CO2	10	15						25																	3	10				
CO3	10	15	25						50																3		15			
CO4													5	10	10						30				3		15			
CO5													5	10	10						30				3		15			
CO6														10	15	25						40				5		15		
Total (in %)	100						100						100						100						100					

Syllabus

GRAPH THEORY-Networks and graphs, Degree, Average degree and Degree distribution, Real networks are sparse, Adjacency Matrix, Weighted and unweighted networks, Bipartite networks, Paths and distances in networks, Connectedness and Components, Clustering coefficient.

RANDOM NETWORKS- The random network model, number of links variable, Degree distribution, Evolution of Random network, Six degrees of separation.

Scale free Property- Power laws and scale-free networks, Hubs, Universality, Ultra-small property, Role of the degree exponent, Generating networks with a pre-defined degree distribution

BARABÁSI-ALBERT MODEL- Growth and preferential attachment, Barabási-Albert Model, Degree dynamics, Degree distribution, The absence of growth or preferential attachment, Non-linear preferential attachment.

EVOLVING NETWORKS- The Bianconi-Barabási model, Measuring fitness, Bose-Einstein condensation, Evolving Networks

DEGREE CORRELATIONS- Assortativity and disassortativity, Measuring degree correlations, Structural cutoffs, Degree correlations in real networks, Generating correlated networks

NETWORK ROBUSTNESS: Percolation theory, robustness of scale-free networks, attack tolerance, cascading failures, modelling cascading failures, building robustness.

Reference Books& web resources

1. Albert-Laszlo Barabasi, “Network Science”, 1st Edition, Cambridge Univ. Press, 2016.
2. Ted G. Lewis, “Network Science: Theory and Practice”, Wiley, 2013
3. Estrada, E., Fox, M., Higham, D.J. and Oppo, G.L.,- “Network Science - Complexity in Nature and Technology”, Springer,2010. https://eravilaipnada.wordpress.com/wp-content/uploads/2016/01/barabasi-2012.pdf

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**GRAPH THEORY**	
1.1	Networks and graphs - introduction	1
1.2	Degree, Average degree and Degree distribution,	1
1.3	Real networks are sparse, Adjacency Matrix	1
1.4	Weighted and unweighted networks, Bipartite networks,	2
1.5	Paths and distances in networks, Connectedness and Components, Clustering coefficient.	2
2	**RANDOM NETWORKS**	
2.1	The random network model, The number of links is variable,	1
2.2	Degree distribution	1

Module No.	Topic	No. of Periods
2.3	Evolution of Random network, Six degrees of separation.	1
3	**SCALE FREE PROPERTY**	
3.1	Power laws and scale-free networks	1
3.2	Hubs, Universality, Ultra-small property Role of the degree exponent	2
3.3	Generating networks with a pre-defined degree distribution	2
4	**BARABÁSI-ALBERT MODEL**	
4.1	Growth and preferential attachment	1
4.2	Barabási-Albert Model	2
4.3	Degree dynamics, Degree distribution	2
4.4	The absence of growth or preferential attachment,	1
4.5	Non-linear preferential attachment	1
5	**EVOLVING NETWORKS**	
5.1	The Bianconi-Barabási model	2
5.2	Measuring fitness, Bose-Einstein condensation	2
5.3	Evolving Networks	1
6	**DEGREE CORRELATIONS**	
6.1	Assortativity and disassortativity	1
6.2	Measuring degree correlations, Structural cutoffs,	1
6.3	Degree correlations in real networks	1
6.4	Generating correlated networks	1
7	**NETWORK ROBUSTNESS**	
7.1	Percolation theory, robustness of scale-free networks	1
7.2	Attack tolerance, cascading failures	1
7.3	Modelling cascading failures, building robustness	1
	Total	**34**

Course Designer(s):

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23DSPX0 INFORMATION RETRIEVAL

Category	L	T	P	Credit
PEC	3	0	0	3

Preamble

The course explores foundational and advanced concepts in Information Retrieval, including search models, indexing, and evaluation techniques. Students will implement real-world IR systems, study modern techniques like neural models and knowledge graphs, and address ethical concerns such as bias and privacy in search systems.

Prerequisite

- 23DS330 – Data Structures and Algorithms
- 23DS210 23DS220, – Probability and Statistics
- 23DS540 - Machine Learning

Course Outcomes

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

CO1	Understand the fundamental concepts of IR, including document representation, retrieval models, and evaluation metrics	Understand
CO2	Apply indexing, vector-space models, and probabilistic retrieval methods to build and test IR systems.	Apply
CO3	Analyze the efficiency and effectiveness of IR models using real-world data.	Analyze
CO4	Apply algorithms for modern web search engines, including PageRank and machine learning-based ranking	Apply
CO5	Apply the ethical and societal impacts of search algorithms, particularly issues like privacy, bias, and fake news	Apply
CO6	Analyze and implement a basic information retrieval system that can handle large-scale document collections	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	L	L	L	-	-	L	-	-	-	M	M	S
CO2	L	M	S	M	L	-	-	L	-	-	-	M	M	M
CO3	L	S	L	S	S	-	-	L	-	-	-	M	S	S
CO4	L	S	S	L	S	-	-	M	-	-	-	S	S	S
CO5	L	M	M	L	L	-	-	S	-	-	-	S	S	M
CO6	L	S	S	S	S	-	-	L	-	-	-	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1						Assignment 1						CAT 2						Assignment 2						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	5	20																							3	10				
CO2	5	10	20						50																3		10			
CO3		10	10	20						50															3	5		15		
CO4													5	10	20										3	5	10			
CO5													5	10	20						50				3		10			
CO6															10	20						50				5		15		
Total (in %)	100						100						100						100						100					

Syllabus

INTRODUCTION TO INFORMATION RETRIEVAL - History and Components of Information Retrieval: Overview of the history of IR systems, Components of IR systems (document representation, indexing, and retrieval) - Open-source IR Frameworks: Popular open-source IR systems (Lucene), Impact of the web on IR - Boolean Retrieval Model: Basics of Boolean retrieval, Boolean operators and query formulation, Advantages and limitations - Vector Space Model: Vector space representation of documents, Term weighting and TF-IDF, Cosine similarity for ranking documents - Evaluation of IR Systems: Evaluation metrics: Precision, Recall, F-measure, Normalized Discounted Cumulative Gain (nDCG), Relevance feedback and query expansion.

INDEXING AND RETRIEVAL METHODS - Inverted Indices: Construction of an inverted index, Efficient processing of sparse vectors, Compressed indices – Pre - processing Techniques: Tokenization, stopword removal, stemming, and lemmatization - Language Models for IR: Basics of Language Model-based IR, Probabilistic IR and the binary independence model, Language models vs other approaches to IR - Relevance Feedback: Concept of relevance feedback, Techniques for relevance feedback and query reformulation - Web Search Basics: Introduction to web search, Crawling and indexing web pages, Index compression and evaluation.

WEB SEARCH AND MODERN RETRIEVAL: PageRank and Link Analysis: Hyperlink-induced topic search (HITS) algorithm, PageRank algorithm, Applications of link analysis in web search - Search Engine Optimization (SEO) and Web Structure: Introduction to SEO and its importance, Measuring web size and structure - Focused Crawling and Meta-Crawlers: Focused crawling techniques - Relevance Scoring and Ranking in Web Search: Ranking methods for web search, Scoring documents based on term importance -
Personalized Search and Collaborative Filtering: Techniques for personalized search, Recommender systems: collaborative filtering and content-based filtering - Handling the “Invisible Web: Challenges in crawling the deep web, Techniques to retrieve information from the deep/invisible web - Hadoop and MapReduce for Large-Scale Retrieval: Introduction to Hadoop, Using MapReduce for processing large datasets.

ADVANCED RETRIEVAL MODELS - Latent Semantic Indexing (LSI): Singular Value Decomposition (SVD), Use of LSI in IR systems, Comparison with vector-space models - Neural Ranking Models: Introduction to neural information retrieval, Comparison of dense vs sparse retrieval models - Knowledge Graphs and Semantic Search: Role of knowledge graphs in modern IR systems, Semantic search using knowledge graphs, Applications in question answering systems.

RESPONSIBLE IR - Bias, Fairness, and Ethics in IR Systems: Understanding bias in search algorithms, Fairness and responsible use of IR technology, Ethical considerations in search - Fake News and Privacy in Search Engines: Identifying and handling fake news, Ensuring user privacy in IR systems

Reference Books & web resources

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze, “Introduction to Information Retrieval”, Cambridge University Press, 2009.

2. Ricardo Baeza-Yates, Berthier Ribeiro-Neto, “Modern Information Retrieval: The Concepts and Technology behind Search”, 2nd Edition, ACM Press Books, 2011.
3. Stefan Büttcher, Charles L. A. Clarke, Gordon V. Cormack, “Information Retrieval: Implementing and Evaluating Search Engines”, MIT Press, 2010.
4. Mark Levene, “An Introduction to Search Engines and Web Navigation”, 2nd Edition, Wiley, 2010.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**INTRODUCTION TO INFORMATION RETRIEVAL**	
1.1	History and Components of Information Retrieval: Overview of the history of IR systems, Components of IR systems (document representation, indexing, and retrieval)	1
1.2	Open-source IR Frameworks: Popular open-source IR systems (Lucene), Impact of the web on IR	1
1.3	Boolean Retrieval Model: Basics of Boolean retrieval, Boolean operators and query formulation, Advantages and limitations	2
1.4	Vector Space Model: Vector space representation of documents, Term weighting and TF-IDF, Cosine similarity for ranking documents	2
1.5	Evaluation of IR Systems: Evaluation metrics: Precision, Recall, F-measure, Normalized Discounted Cumulative Gain (nDCG), Relevance feedback and query expansion	3
2	**INDEXING AND RETRIEVAL METHODS**	
2.1	Inverted Indices: Construction of an inverted index, Efficient processing of sparse vectors, Compressed indices	2
2.2	Preprocessing Techniques: Tokenization, stopword removal, stemming, and lemmatization	1
2.3	Language Models for IR: Basics of Language Model-based IR, Probabilistic IR and the binary independence model, Language models vs other approaches to IR	2
2.4	Relevance Feedback: Concept of relevance feedback, Techniques for relevance feedback and query reformulation	1
2.5	Web Search Basics: Introduction to web search, Crawling and indexing web pages, Index compression and evaluation	2
3	**WEB SEARCH AND MODERN RETRIEVAL**	
3.1	PageRank and Link Analysis: Hyperlink-induced topic search (HITS) algorithm, PageRank algorithm, Applications of link analysis in web search	1
3.2	Search Engine Optimization (SEO) and Web Structure: Introduction to SEO and its importance, Measuring web size and structure	1
3.3	Focused Crawling and Meta-Crawlers: Focused crawling techniques	1
3.4	Relevance Scoring and Ranking in Web Search: Ranking methods for web search, Scoring documents based on term importance	2
3.5	Personalized Search and Collaborative Filtering: Techniques for	2

	personalized search, Recommender systems: collaborative filtering and content-based filtering	
3.6	Handling the “Invisible Web: Challenges in crawling the deep web, Techniques to retrieve information from the deep/invisible web	1
3.7	Hadoop and MapReduce for Large-Scale Retrieval: Introduction to Hadoop, Using MapReduce for processing large datasets	1
4	**ADVANCED RETRIEVAL MODELS**	
4.1	Latent Semantic Indexing (LSI): Singular Value Decomposition (SVD), Use of LSI in IR systems, Comparison with vector-space models	2
4.2	Neural Ranking Models: Introduction to neural information retrieval, Comparison of dense vs sparse retrieval models	2
4.3	Knowledge Graphs and Semantic Search: Role of knowledge graphs in modern IR systems, Semantic search using knowledge graphs, Applications in question answering systems	2
5	**RESPONSIBLE IR**	
5.1	Bias, Fairness, and Ethics in IR Systems: Understanding bias in search algorithms, Fairness and responsible use of IR technology, Ethical considerations in search	2
5.2	Fake News and Privacy in Search Engines: Identifying and handling fake news, Ensuring user privacy in IR systems	2
	Total	**36**

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23DS1A0	DATA REPORTING	Category	L	T	P	Credit
		EEC	1	0	0	1

Preamble

This course aims at providing introduction to data reporting tools and hands on training to report data in appropriate formats.

Prerequisite

- Nil

Course Outcomes

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

CO1: Explain the basics of data reporting and data integration — Understand

CO2: Use data reporting tools to generate reports with available data — Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2
CO1.	S	M	S	M	M	L	L	L	M	L	L	M	M	S
CO2.	M	S	M	S	L	L	M	M	L	L	M	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Internal						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10	20				10	10	20			
CO2	10	20	30				10	20	30			
Total (in %)	100						100					

Syllabus

Basics of data reporting - Data integration from different sources - Generating reports/ Dashboard - Measuring domain specific KPIs - Sample data and project work
Tools: Excel, Tableau

Reference Books

1. Winston, W., "Microsoft Excel 2013 Data Analysis and Business Modeling: Data Analysis and Business Modeling", Pearson Education, 2014

2. Sleeper, R.,. Practical tableau: 100 tips, tutorials, and strategies from a Tableau zen master. " O'Reilly Media, Inc.", 2018.

Course Designers:

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		Category	L	T	P	Credit
23DS1B0	**TABLEAU IN DATA VISUALIZATION**	EEC	1	0	0	1

Preamble

This course aims at providing introduction to applications of tableau in data visualisation and hands on training to visualise data in diverse formats using tableau.

Prerequisite

- Nil

Course Outcomes

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

CO1: Explain the basics visualization tools of Tableau — Understand

CO2: Use tableau to generate visualisation reports with available data — Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2
CO1	S	M	S	M	M	L	L	L	M	L	L	M	M	S
CO2.	M	S	M	S	L	L	M	M	L	L	M	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Internal						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10	20				10	10	20			
CO2	10	20	30				10	20	30			
Total (in %)	100						100					

Syllabus

Basics of Business Intelligence-Introduction to Tableau - Connecting to Data Sources-Querying data from Data Sources- Data wrangling- Understanding the Workspace-Features(Attributes, Dimensions and Calculate fields)- Chart Features-Filters and Marks-Tableau Chart Demonstration Examples-Sample data and project work.

Reference Books

1. Marleen Meier, David Baldwin,"Mastering Tableau 2021: Implement advanced business intelligence techniques and analytics with Tableau",Packt Publishing,2021.
2. Knaflic, Cole Nussbaumer,"Storytelling with data a data visualization guide for business professionals",Wiley Publisher,2022.
3. Lindy Ryan,"Visual Data Storytelling with Tableau",Addison-Wesley Professional,2018.

Course Designers:

1. <Ms.Christy Britto, Morgan Stanley> < jbchristy@gmail.com>
2. <Ms. R. Saraswathy Meena> <rsmca@tce.edu>

		Category	L	T	P	Credit
23DS1C0	**NODE JS**	EEC	1	0	1	1

Preamble

This course provides an introduction to Node.js, a powerful JavaScript runtime built on Chrome's V8 engine. Students will learn the core concepts of Node.js, such as its event-driven architecture, non-blocking I/O, and the Node.js execution model. The course also covers the Express.js framework for building web applications, connecting to databases like MongoDB or MySQL, and error handling techniques. Students will engage in practical labs, creating APIs, working with files, and managing processes using PM2.

Prerequisite

- 23DS570 - Web Technology Lab

Course Outcomes

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

CO1	Apply the fundamental concepts of Node.js, including its event-driven architecture, core modules, and the Node Package Manager	Apply
CO2	Develop advanced Node.js applications using asynchronous programming, Express.js, and database integration	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2
CO1	S	M	S	M	M	L	L	L	M	L	L	M	M	S
CO2	M	S	M	S	L	L	M	M	L	L	M	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Internal						Terminal					
Bloom's level	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	**10**	**10**	**20**				**10**	**10**	**20**			
CO2	**10**	**20**	**30**				**10**	**20**	**30**			
Total (in %)	**100**						**100**					

Syllabus

Introduction and Fundamentals

Introduction to Node.js: Basics, advantages, and event-driven architecture.

Core Concepts of Node.js: Execution model, asynchronous programming, and non-blocking I/O.

Modules in Node.js: Overview of built-in modules like fs, path, and http.

Introduction to NPM: Package management, installation, and significance of package.json and package-lock.json.

Advanced Concepts and Practical Applications

Asynchronous Programming: Callbacks, Promises, and async/await syntax.

Express.js Framework: Building web applications, routing, and middleware.

Working with Databases: Connecting to MongoDB and MySQL, CRUD operations.

Error Handling and Debugging: Error handling strategies in Node.js applications.

PM2 Process Manager: Managing Node.js processes and monitoring application performance.

Lab (Hands-on - Basic)

Setting up the Environment: Installing Node.js and npm; running the first application.
Modules in Node.js: Creating and using custom modules; practice with built-in modules.
Working with the File System: Reading/writing files using the fs module.
Working with HTTP: Creating a basic HTTP server and serving static files.

Lab (Hands-on - Advanced)

Asynchronous Programming: Building an application using callbacks, Promises, and async/await.
Express.js Framework: Setting up an Express app and creating routes.
Working with Databases: Performing CRUD operations and managing data.
Error Handling and Debugging: Implementing error handling and debugging techniques.
PM2 Process Manager: Installing, configuring, and monitoring Node.js apps with PM2.
Building a Simple API: Creating RESTful routes, handling JSON data, and using Postman for testing.

Reference Books

1. Andrew Mead *"Learning Node.js Development"* ,Packt Publishing, 2018.
2. Mario Casciaro, "Luciano Mammino *Node.js Design Patterns",* Second Edition, Packt Publishing, 2016.
3. Jim R. Wilson *,"Node.js 8 the Right Way: Practical, Server-Side JavaScript That Scales",* Pragmatic Bookshelf, 2018.
4. Mike Cantelon, Marc Harter, T.J. Holowaychuk, Nathan Rajlich *, "Node.js in Action",* Second Edition, Manning Publications, 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.	**Introduction and Fundamentals**	
1.1	Introduction to Node.js	1
1.2	Core Concepts of Node.js	1
1.3	Modules in Node.js and Introduction to NPM	1
2.	**Advanced Concepts and Practical Applications**	
2.1	Asynchronous Programming	1
2.2	Express.js Framework	1
2.3	Error Handling and Debugging	1
2.4	Working with Databases and PM2 Process Manager	1
3.	**Lab (Hands-on - Basic)**	
3.1	Setting up the Environment and Modules in Node.js	1
3.3	Working with the File System and Working with HTTP	1
4.	**Lab (Hands-on - Advanced)**	
4.1	Asynchronous Programming	1
4.2	Express.js Framework	1
4.3	Working with Databases	1
4.4	Error Handling and Debugging	1
4.5	PM2 Process Manager and Building a Simple API	1
Total		**14**

Course Designers:

1. **Faculty :** Dr.C.Mahadevi.,Assistant Professor, Applied Mathematics and Computational Science(AMCS) in Data Science, cmids@tce.edu
2. **Industry Expert :** Mr.Prabuganesan.K, Team Lead , Chain-Sys (India) Pvt. Ltd, prabuganesan.kamaraj@chainsys.com .

23DS1D0	PROMPT ENGINEERING	Category	L	T	P	Credit
		EEC	1	0	0	1

Preamble

This course provides an introduction to prompt engineering techniques, focusing on crafting effective prompts for AI models. It includes hands-on training for optimizing prompts and evaluating their performance across various applications.

Prerequisite

- Nil

Course Outcomes

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

CO1: Develop and implement effective prompting techniques to optimize AI model responses across various applications — Apply

CO2: Assess and evaluate the security, alignment, and performance of prompting strategies through practical case studies and benchmarking methodologies. — Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2
CO1.	S	M	S	M	M	L	L	L	M	L	L	M	M	S
CO2.	M	S	M	S	L	L	M	M	L	L	M	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Internal						Terminal					
Bloom's level	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	10	20				10	10	20			
CO2	10	20	30				10	20	30			
Total (in %)	100						100					

Syllabus

Introduction to Prompts: Key Terminology and Components, Historical Context of Prompting
Text-Based Techniques: In-Context Learning, Zero-Shot, Thought Generation
Advanced Techniques: Decomposition, Ensembling, Self-Criticism.
Answer Engineering: Shape, Space, and Extraction.
Multilingual Prompting and Techniques Extensions: Tool Use Agents, Code-Generation Agents.
Retrieval Augmented Generation Prompting Issues: Security Risks and Alignment Challenges Benchmarking Techniques - Case Study

Reference Books

1. **El Amri, A. (2024). LLM Prompt Engineering for Developers. Packt Publishing.**

2. **Berryman, J., & Ziegler, A. (2024). Prompt Engineering for LLMs. O'Reilly Media.**

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to Prompts**	
1.1	Key Terminology and Components	1
1.2	Historical Context of Prompting	1
2.	**Text-Based Techniques**	
2.1	In-Context Learning, Zero-Shot	1
2.2	Thought Generation	1
3.	**Advanced Techniques**	
3.1	Decomposition, Ensembling, Self-Criticism	2
4.	**Answer Engineering**	
4.1	Shape, Space, and Extraction.	2
5.	**Multilingual Prompting and Techniques Extensions**	
5.1	Tool Use Agents	1
5.2	Code-Generation Agents.	1
6.	**Retrieval Augmented Generation Prompting Issues**	
6.1	Security Risks and Alignment Challenges Benchmarking Techniques	1
6.2	Case Study	1
Total		**12**

Course Designers:

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