AC –
Item No. –

As Per NEP 2020

University of Mumbai

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Syllabus for Major Vertical – 1, 4, 5 & 6		
Name of the Programme – B.E. (Computer Science and Engineering (Data Science))		
Faulty of Engineering		
Board of Studies in Computer Science and Engineering (Data Science)		
U.G. Second Year Programme	Exit Degree	U.G. Diploma in Engineering-Computer Science and Engineering (Data Science).
Semester		III & IV
From the Academic Year		2025-26

University of Mumbai

(As per NEP 2020)

Sr.No.	Heading	Particulars
1	**Title of program** **O:_____**	**B.E. (Computer Science and Engineering (Data Science))**
2	**Exit Degree**	**U.G. Diploma in Engineering-Computer Science and Engineering (Data Science).**
3	**Scheme of Examination** **R: _____**	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	**Standards of Passing** **R: _____**	**40%**
5	**Credit Structure** **R: _____**	**Attached herewith**
6	**Semesters**	**Sem. III & IV**
7	**Program Academic Level**	**5.00**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2025-26**

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Sd/-	Sd/-	Sd/-
Dr. Subhash K. Shinde	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS Chairman, Computer Engineering	**Associate Dean**	**Dean**
Faculty of Science & Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The second-year engineering course is a core training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, multidisciplinary minor, and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program and skills required for the Computer Science and Engineering (Data Science) Branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends in technology. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Computer Science and Engineering (Data Science) in Engineering for open electives and multidisciplinary minor courses in the third and fourth semesters. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Course Cover Computer Science and Engineering (Data Science) core courses. Also, OE and MDM where a pool of subjects are given for selection. Considering the present scenario, diverse choices need to be made available to fulfill the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. Ability enhancement can be achieved in Undergraduate training by giving an objective viewpoint to the learning process and transitioning a learner from a rote learner to a creative professional. for the purpose Design Thinking is introduced in the First Semester to orient a journey learner to become a skilled professional. Considering the NEP-2020 structure of award of Certificate & Diploma at multiple exit-point pools of Vocational skills is arranged for giving exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught, which will enhance the learner's learning process. NEP 2020 grading system enables a much-required shift in focus from teacher-centric to continuous-based learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation, which will enhance the quality of education. Credit assignment for courses is based on a 15-week teaching-learning process for NEP 2020, however, the content of courses is to be taught in 12-13 weeks, and the remaining 2-3 weeks are to be utilized for revision, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the second-year syllabus must not be heavily loaded to the learner and it is of utmost importance that the learner entering into the second year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Second Year of Engineering from the academic year 2054-26. Subsequently, this system will be carried forward for Third Year and Final Year Engineering in the academic years 2026-27, and 2027-28, respectively.

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Faculty of Science & Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

Under Graduate Diploma in Engineering- <u>Computer Science and Engineering (Data Science).</u>

Credit Structure (Sem. III & IV)

	R: _____C									
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.0	III	PCC301:3 PCC302:3 PCC303:3 PCC304:3 PCL301: 1 PCL302:1	--	--	OE:2	--	VEC: 2 HSL: 2	CEP: 2	22	**UG Diploma 45**
	R:_____D									
	IV	PCC401:3 PCC402:3 PCC403:3 PCL401:1 PCL402:1	--	MDM: 4	OE:2	VSEC:2	VEC: 2 EEM:2	--	23	
	Cum Cr.	25	--	4	4	2	*2+2+2+2*	2	45	

Exit option: Award of UG Diploma in Major and MDM with 90 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one third year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

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Sem. - III

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S.E. Computer Science and Engineering (Data Science) Scheme

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Program Structure for Second Year of Computer Science and Engineering (Data Science)

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER III

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2173111	Mathematics for Computer Engineering	2	--	1	2	1	--	3
2173112	Discrete Structures and Graph Theory	3	–	--	3	--	--	3
2173113	Analysis of Algorithm	3	--	--	3	--	--	3
2173114	Computer organization & Architecture	3	--	--	3	--	--	3
2173311	Open Elective	2#	--	--	2	--	--	2
2173115	Analysis of Algorithm Lab	--	2	--	--	--	1	1
2173116	Computer Organization and Architecture Lab	--	2	--	--	--	1	1
2173611	Full Stack Java Programming	--	2*+2	--	--	--	2	2
2993511	Entrepreneurship Development	--	2*+2	---	--	--	2	2
2993512	Environmental Science for Engineers	--	2*+2	--	--	--	2	2
Total		**13**	**16**	**01**	**13**	**01**	**08**	**22**

* Two hours of practical class to be conducted for full class as demo/discussion.
Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

#Institute shall offer a course for MDM from other Engineering Boards.

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Program Structure for Second Year of Computer Science and Engineering (Data Science)

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER III

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2173111	Mathematics for Computer Engineering	20	20	40	60	2	25	--	125
2173112	Discrete Structures and Graph Theory	20	20	40	60	2	--	--	100
2173113	Analysis of Algorithm	20	20	40	60	2	--	--	100
2173114	Computer organization & Architecture	20	20	40	60	2	--	--	100
2173311	Open Elective	20	20	40	60	2	--	--	100
2173115	Analysis of Algorithm Lab	--	--	--	--	--	25	25	50
2173116	Computer Organization and Architecture Lab	--	--	--	--	--	25	25	50
2173611	Full Stack Java Programming	--	--	--	--	--	50	25	75
2993511	Entrepreneurship Development	--	--	--	--	--	50	--	50
2993512	Environmental Science for Engineers	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**225**	**75**	**800**

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Program Structure for Second Year of Computer Science and Engineering (Data Science)

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER IV

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2174111	Computational Theory	3	--	--	3	--	--	3
2174112	Database Management System	3	–	--	3	--	--	3
2174113	Operating System	3	--	--	3	--	--	3
MDC401	Multidisciplinary minor	3	--	--	3	--	--	3
2174311	Open Elective	2#	--	--	2	--	--	2
2174114	Database Management System Lab	--	2	--	--	--	1	1
2174115	Operating System Lab	--	2	--	--	--	1	1
MDL401	Multidisciplinary minor	--	2	--	--	--	1	1
2174411	Mini Project	--	4	--	--	--	2	2
2994511	Business Model Development	--	2*+2	--	--	--	2	2
2994512	Design Thinking	--	2*+2	--	--	--	2	2
Total		**13**	**18**	**01**	**13**	**01**	**09**	**23**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Students must select course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

#Institute shall offer a course for MDM from other Engineering Boards.

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Program Structure for Second Year of Computer Science and Engineering (Data Science)

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER IV

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw)	Oral & Pract.	Total
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2174111	Computational Theory	20	20	40	60	2	--	--	100
2174112	Database Management System	20	20	40	60	2	--	--	100
2174113	Operating System	20	20	40	60	2	--	--	100
MDC401	Multidisciplinary minor	20	20	40	60	2	--	--	100
2174311	Open Elective	20	20	40	60	2	--	--	100
2174114	Database Management System Lab	--	--	--	--	--	25	25	50
2174115	Operating System Lab	--	--	--	--	--	25	25	50
MDL401	Multidisciplinary minor Lab	--	--	--	--	--	25	--	25
2174411	Mini Project-I	--	--	--	--	--	50	25	75
2994511	Business Model Development	--	--	--	--	--	50	--	50
2994512	Design Thinking	--	--	--	--	--	50	--	50
Total		**100**	**100**	**200**	**300**	**10**	**250**	**75**	**800**

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Vertical – 1
Major

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173111	Mathematics for Computer Engineering	2	-	1	2	-	1	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2173111	Mathematics for Computer Engineering	20	20	40	60	2	25	--	125

Rationale :

The goal of this course is to achieve conceptual understanding and to retain the best applied mathematics for Computer Science and Engineering (Data Science) and technology. The syllabus is designed to provide the basic tools of mathematics mainly for the purpose of modelling the Computer Science and Engineering (Data Science) problems mathematically and obtaining solutions. This is engineering mathematics course which mainly deals with topics concern to Computer Science and Engineering (Data Science) and technology.

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Course Objectives: Six Course Objectives

1. To introduce concepts and fundamentals Matrix algebra for engineering problems
2. To introduce concepts of Linear and Non-linear programming problems of optimization and its applications.
3. To introduce the concept of modular arithmetic.
4. To enhance the skills to expand Fourier series for periodic functions with various period.
5. To develop the proficiency in statistical techniques arising in engineering applications.
6. To familiarize with the concepts of probability distributions with its applications in engineering and science.

Course Outcomes: Six Course outcomes (Based on Blooms Taxonomy)
On successful completion, of course, learner/student will be able to:

1. Apply the concepts of eigenvalues and eigenvectors in engineering problems.
2. Solve Linear and Non-Linear Programming Problems for optimization of engineering problems.
3. Analyze modular arithmetic for security applications.
4. Expand the periodic function by using the Fourier series for real-life problems and complex engineering problems.
5. Apply the concept of Correlation and Regression to the engineering problems in data science, machine learning, and AI.
6. Apply the concept of probability distribution to engineering problems, mostly used in varied applications in engineering and science.

DETAILED SYLLABUS:

Sr. No	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Complex Numbers, Probability, Central tendencies and dispersion in Statistical techniques, Baye's theorem, Random variable, Discrete and Continuous random variables.		
I	**Linear Algebra (Theory of Matrices)**	1. Characteristic Equation, Eigenvalues and Eigenvectors, and properties (without proof) 2. Cayley-Hamilton Theorem (without proof), verification and reduction of higher degree polynomials 3. Similarity of matrices, diagonalizable and non-diagonalizable matrices **Self-learning Topics**: Derogatory and non-derogatory matrices, Functions of Square Matrix, Linear Transformations, Quadratic forms.	**5**	**CO1**
II	**Linear and Non-Linear Programming Problems**	1. Types of solutions, Standard and Canonical of LPP, Basic and Feasible solutions, slack variables, surplus variables, Simplex method. 2. NLPP with one and two equality constraint (two or three variables) using the method of Lagrange's multipliers **Self-learning Topics**: Sensitivity Analysis, Big-M method, Artificial variables, Kuhn-Tucker conditions	**5**	**CO2**
III	**Modular Arithmetic**	1. Introduction to Congruence, Linear congruence, reminder theorem, solving polynomials, system of linear congruence 2. Eluer's theorem, Fermat's little theorem, Application of congruence-RSA algorithm. **Self-learning Topics**: Divisiblility, GCD, properties of prime numbers, fundamental theorem of arithmetic.	**4**	**CO3**
IV	**Fourier Series**	1. Dirichlet's conditions, Fourier series of periodic function with period 2π and $2l$. 2. Fourier series of even and odd functions. **Self-learning Topics:** Orthogonal and orthonormal set of functions, Complex form of Fourier Series, Half range Sine and Cosine Series.	**4**	**CO4**
V	**Statistical Techniques**	1. Karl Pearson's coefficient of correlation (r). 2. Spearman's Rank correlation coefficient (R) (with repeated and non-repeated ranks). 3. Lines of regression, fitting of first-degree curves. **Self-learning Topics:** Covariance, Fitting of second-degree and exponential curve.	**4**	**CO5**
VI	**Probability**	1. Moment generating function, Raw moments. 2. Poisson Distribution, Normal Distribution **Self-learning Topics:** Skewness and Kurtosis of distribution (data), types of distribution and their application.	**4**	**CO6**

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Books:

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication.
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited.
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication
4. Probability, Statistics and Random Processes, T. Veerarajan, Mc. Graw Hill education.
5. Number theory, M. G. Nadkarni and J. S. Dani, Tata Mc. Graw Hill education.

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/111/104/111104085/
2.	https://nptel.ac.in/courses/111/106/111106139/
3.	https://www.youtube.com/watch?v=2CP3m3EgL1Q
4.	https://www.youtube.com/watch?v=Hw8KHNgRaOE
5.	https://nptel.ac.in/courses/111/105/111105041/

Assessment: Note: Tutorial shall be conducted batch wise

Term Work: General Instructions:

1. Students must be encouraged to write at least 6 class tutorials on entire syllabus.

The tutorials should be conducted batch wise.

2. A group of 4-6 students should be assigned a ***self-learning topic*** to prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering Mathematics.

This project should be graded for 10 marks depending on the performance of the students.

3. The distribution of Term Work marks will be as follows –
   a. Attendance (Theory and Tutorial) : 05 marks
   b. Class Tutorials on entire syllabus : 10 marks
   c. Mini project : 10 marks

Internal Assessment (IA) for 40 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

End Semester Internal Examination for 40 marks:

Question paper format:

1. Question Paper will comprise of a total of **six questions each carrying 20 marksQ.1** will be **compulsory** and should **cover maximum contents of the syllabus**
2. **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
3. A total of **Three questions** needs to be answered.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173112	Discrete Structures and Graph Theory	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract. / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
2173112	Discrete Structures and Graph Theory	20	20	40	60	2	--	--	100

Rationale:
Mathematics forms the foundation of computer science and engineering. The study of Discrete Structures and Graph Theory enables students to develop strong logical reasoning, combinatorial techniques, and mathematical structures that are essential in programming, algorithm design, networking, database design, artificial intelligence, and cryptography.

Course Objectives:

1) Cultivate clear thinking and creative problem solving.
2) Thoroughly train in the construction and understanding of mathematical proofs. Exercise common mathematical arguments and proof strategies.
3) To apply graph theory in solving practical problems.
4) Thoroughly prepare for the mathematical aspects of other Computer Science and Engineering (Data Science) courses.
5) Solve real-world problems using counting principles, recurrence relations.
6) Strengthen mathematical foundations for research and higher studies in Computer Science and Engineering (Data Science).

Course Outcomes:

1) Understand the notion of mathematical thinking, mathematical proofs and to apply them in problem solving using set theory and logic.
2) Apply properties of Relation sets in real-life problem-solving domains.
3) Apply properties of Function sets in real-life problem-solving domains
4) Apply counting principles, including the Pigeonhole Principle and Inclusion-Exclusion Principle, to solve combinatorial problems.
5) Apply algebraic structure for a given mathematical problem.
6) Apply graph theory in solving computing problems.

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DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Basic Set Theory, Logical Operators, Truth Tables, Cartesian product, Types of Functions. Basic Algebra and Number Theory, Fundamental Counting Principle, Permutations, Combinations. Graph Basics.	1	
I	**Crisp Set Theory and Logic**	**Set Theory:** Sets, Subsets, Universal and Empty Sets, Set Operations, Set Representation, Laws of Set theory. **Logic:** Propositional Logic, Predicate Logic, Quantifiers (Universal and Existential). **Types of Mathematical Proof:** Direct proof, Proof by contradiction, Proof by deduction, Proof by cases, Proof by exhaustion, Proof by counterexample, Mathematical induction. **Self-learning Topics:** PROLOG / LISP programming to create expert system using Propositional and Predicate Logic, Other types of logic and sets.	7	CO1
II	**Mathematical Relations**	**Relations:** Definition, Representation of Relations, Properties of Relations, Equivalence Relations, Equivalence Classes, Closures of Relations, Warshall's algorithm. **Posets and Lattice:** Partial Order Relations, Poset, Hasse Diagram, Chain and Anti chains, Lattice, Types of Lattices, Sub lattice. **Self-learning Topics:** Practical applications of relations in real life in the field of Database Management, Economics, Social Network, Sports, Medical Diagnosis, Weather, etc.	8	C02
III	**Functions**	**Functions:** Types: Injective, Surjective, and Bijective Functions. Composition, Inverse Functions. Real life applications of Functions. **Self-learning Topics:** Practical applications of function in Neural Network, Determining risk factors for insurance rates, Taxes and tax brackets, Vending machines, etc.	3	CO3
IV	**Counting**	Pigeonhole Principle, Inclusion-Exclusion Principle. Recurrence relations, Solving recurrence relations **Self-learning Topics:** Applications of Recurrence Relations – Analysis of recursive algorithms in computing. Combinatorial Problem Solving – Using counting techniques in probability and decision-making.	5	CO4
V	**Algebraic Structures**	Algebraic structures with one binary operation: Semi group, Monoid, Groups, Subgroups, Abelian Group, and Cyclic group. Algebraic structures with two binary operations: Ring. **Self-learning Topics:** Error Correcting codes.	7	CO5

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VI	**Graph Theory**	Types of graphs, Graph Representation, Sub graphs, Operations on Graphs, Walk, Path, Circuit, Connected Graphs, Disconnected Graph, Components, Homomorphism and Isomorphism of Graphs, Euler and Hamiltonian Graphs, Planar Graph, Cut Set, Cut Vertex, Real life applications of Graph Theory. **Self-learning Topics**: Network Flow Problems – Understanding flow in networks and its optimization. Graph Coloring Applications in Scheduling – Use of graph coloring in timetabling and resource allocation. Optimization Techniques – Application of graphs in shortest path problems, spanning trees, and clustering.	8	CO6

Text Books:

1. Susanna S. Epp, "Discrete Mathematics with Applications", 5th Edition, Cengage Publications.
2. Ralph P. Grimaldi, "Discrete and Combinatorial Mathematics", 5th Edition, Pearson Publications.
3. Edgar Goodaire and Michael Parmenter, "Discrete Mathematics and Graph Theory", 3rd Edition, Pearson Publications.

Reference Books:

1. Kenneth A. Ross, "Discrete Mathematics", 5th Edition, Pearson Publications.
2. Swapan Kumar Sarkar, "Textbook of Discrete Mathematics", 9th Edition, S. Chand Publications.
3. Bernad Kolman, Robert Busby, Sharon Cutler Ross, Nadeem-ur-Rehman, "Discrete Mathematical Structures", 6th Edition, Pearson Education.
4. T. Veera Rajan, "Discrete mathematics with Graph Theory and Combinatorics", McGraw Hill Publications.
5. C. L. Liu "Elements of Discrete Mathematics", second edition 1985, McGraw-Hill Book Company. Reprinted 2000

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/106106094
2.	https://nptel.ac.in/courses/106108227
3.	https://nptel.ac.in/courses/106106183
4.	https://nptel.ac.in/courses/106103205
5.	https://nptel.ac.in/courses/111107058

Assessment:

- Internal Assessment Test (IAT) for 40 Marks:
  - IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.
- End Semester Theory Examination for 60 Marks:

  Question paper format :
  - Question Paper will comprise a total of six questions each carrying 15 marks Q.1 will be compulsory and should cover the maximum contents of the syllabus.
  - Remaining questions will be mixed in nature (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules).
  - A total of four questions need to be answered.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173113	Analysis of Algorithm	2		-	2	-	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	IAT-I + IAT-II (Total)					
2173113	Analysis of Algorithm	20	20	40	60	2	--	--	100

Course Objectives:

1. To provide mathematical approaches for Analysis of Algorithms
2. To understand and solve problems using various algorithmic approaches
3. To analyze algorithms using various methods

Course Outcomes:

1. Evaluate the time and space complexity of algorithms.
2. Implement the Divide and Conquer strategy and assess its complexity.
3. Utilize the Greedy algorithm approach and determine its efficiency.
4. Develop solutions using Dynamic Programming and examine its complexity.
5. Employ Backtracking and Branch and Bound techniques.
6. Apply String Matching algorithms for pattern searching

Prerequisite: Data structure concepts

DETAILED SYLLABUS:

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Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	**Introduction**	Performance analysis- Master Method, space, and time complexity Growth of function, Big-Oh, Omega Theta notation Mathematical background for algorithm analysis. Analysis of selection sort, insertion sort. **Self-learning Topics:** Complexity class: Definition of P, NP, NP-Hard, NP-Complete	**4**	CO1
II	**Divide and Conquer Approach**	General method, Merge sort, Quick sort, Analysis of Binary search. **Self-learning Topics:** Finding minimum and maximum algorithms and their Analysis, Strassen's Algorithm, real life applications of all algorithms	**5**	CO2
III	**Greedy Method Approach**	General Method, Single source shortest path: Dijkstra Algorithm Fractional Knapsack problem, Minimum cost spanning trees: Kruskal and Prim's algorithms **Self-learning Topics:** Job sequencing with deadlines, real life applications of all algorithms	**5**	CO3

IV	**Dynamic Programming Approach**	General Method, Multistage graphs, All pair shortest path: Floyd Warshall Algorithm, 0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence. **Self-learning Topics:** Bellman Ford Algorithm, real life applications of all algorithms	**8**	CO4
V	**Backtracking and Branch and bound**	General Method, Backtracking: N-queen problem, Sum of subsets,Graph coloring. Branch and Bound: Travelling Salesperson Problem, 15 Puzzle problem **Self-learning Topics:** Real life applications of all algorithms	**7**	CO1
VI	**String Matching Algorithms**	The Naïve string-matching algorithm, The Rabin Karp algorithm, The Knuth-Morris-Pratt algorithm **Self-learning Topics:** Real life applications of all algorithms	**3**	CO2

Text Books:

1. T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005

2. Ellis Horowitz, Sartaj Sahni, S. Rajsekaran. "Fundamentals of computer algorithms" University Press.

Reference Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw- Hill Edition.
2. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI

Online References:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/106/106/106106131/
2.	https://swayam.gov.in/nd1_noc19_cs47/preview
3.	https://www.coursera.org/specializations/algorithms
4.	https://www.mooc-list.com/tags/algorithms

Assessment:

- **Internal Assessment (IA) for 40 marks:**

  IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Examination for 60 Marks:

Question paper format:

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **Three questions** needs to be answered.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173114	Computer Organization & Architecture	3	-	-	3	-	-	3

Course Code	Course Name	Evaluation Scheme (Theory)					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
2173114	Computer Organization & Architecture	20	20	40	60	2	-	-	100

Pre-requisite.	Fundamental of Mathematics

Course Objective: To study the fundamentals of number system and arithmetic operations. To equip students with the foundational knowledge of computer organization and architecture, fostering an understanding of how hardware and software components collaborate to execute tasks, and preparing them to design and optimize computing systems for real-world applications.

Course Outcomes (CO): At the End of the course students will be able to

CO.1	Conceptualize basic computer structure with its models.
CO.2	Design algorithms to solve ALU operations
CO.3	Comprehend processor organization with various control signal design methods of CPU with comparative analysis.
CO.4	Design memory systems with analysis of mapping techniques for cache memory.
CO.5	Explore different types of I/O buses, examine data transfer methods, and assess arbitration techniques for optimized system performance.
CO.6	Analyze different parallel organizations that includes pipelined and parallel processors

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DETAIL SYLLABUS:

Sr. No.	Name of the Module	Topics	Hrs	CO Mapping
1	**Computer Fundamentals**	**Number Systems:** Binary. Octal and Hexadecimals. **Binary Number representation:** Sign Magnitude, 1's and 2's Compliment representation. **Logic Gates:** AND, OR, NOT, NAND, NOR, EX-OR. Basic Organization of Computer, Von Neumann model.	**4**	CO 1
2	**ALU Operations**	**ALU Operation:** Addition and Subtraction on Binary, Octal, Hexadecimal number. Booth's Algorithms, Restoring and Non restoring division algorithm. IEEE 754 Floating point representation and conversation.	**8**	CO 2
3	**Processor Organization and Control Unit Design**	**8086 Processor**: Architecture of 8086 processor, Register Organization, Instruction formats, instruction cycle, addressing modes. **Control Unit:** Instruction interpretation and sequencing, Micro-programmed and hardwired control unit design methods. Microinstruction sequencing and execution, Micro programs. **RISC and CISC:** Introduction to RISC and CISC architectures and design issues.	**8**	CO 3

4	**Memory Systems Organization**	Introduction to Memory and Memory parameters. Classifications of primary and secondary memories. Types of RAM and ROM, Memory hierarchy and characteristics, Virtual Memory: Segmentation and Paging Cache memory: Concept, hierarchy (L1, L2, L3), mapping techniques. Cache Coherency and technique to resolve it. Interleaved and Associative memory. **Self-Study** : Case study of Pentium Processor Cache Memory Model (MESI Protocol)	**7**	CO 4
5	**I/O Organization**	Buses: Types of Buses, Bus Arbitration, Bus standards and its comparative study I/O Interface, I/O channels, I/O modules and IO processor, Types of data transfer techniques: Programmed I/O, Interrupt driven I/O and DMA.	**4**	CO 5
6	**Parallel Processing**	Advanced Processor Models(80386DX): Real Model, Protected Model, Virtual Model Pipelined Architecture: Pipeline Stages, Superscalar architecture Pipeline Hazards, Mitigation of Hazards with branch prediction and data forwarding techniques, Amdahl's Law Introduction to parallel processing concepts, Flynn's classifications. **Self-Study:** Superscalar Architecture: Case study of Pentium processor and GPGPU architecture.	**8**	CO 6

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Text Books:

Sr. No	Title	Edition	Authors	Publisher	Year
1	Modern Digital Electronics	4th	R P Jain	Tata McGraw-Hill	2009
2	Computer Organization	5th	Carl Hamacher, Zvonko Vranesic	Tata McGraw-Hill	2002
3	Computer Architecture and Organization	3rd	John P. Hayes	Tata McGraw-Hill	2012
4	Computer Organization and Architecture: Designing for Performance	8th	William Stallings	Pearson	2010
5	Microprocessors and Interfacing	3rd	Douglas V Hall	Tata McGraw-Hill	2017
6	The 80386, 80486, and Pentium Microprocessor: Hardware, Software, and Interfacing	3rd	Walter Triebel	Pearson	1997
7	Pentium Pro Processor System Architecture	3rd	Tom Shanely	Addison Wesley	1996

Reference Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Structured Computer Organization	6th	Andrew S. Tanenbaum	Pearson	2012
2	Computer Architecture and Organization: Design Principles and Applications	2nd	B. Govindarajulu	McGraw Hill	Paperback-2017
3	Advance Computer Architecture: Parallelism, Scalability, Programmability	3rd	Kai Hwang	Tata-McGraw Hill	2017

4	Microcomputer System The 8086/8088 family	2nd	Liu and Gibson	Pearson	2015
5	Programmer's reference Manual for IBM Personal Computers	1st	Steven Armburst	Tata-McGraw Hill	

Online References:

Sr. No.	Website Name
1.	https://www.classcentral.com/course/swayam-computer-organization-and-architecture-a-pedagogical-aspect-9824
2.	https://nptel.ac.in/courses/106/103/106103068/
3.	https://www.coursera.org/learn/comparch
4.	https://www.edx.org/learn/computer-architecture

Assessment:

- **Internal Assessment (IA) for 40 marks:**

  IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **End Semester Examination for 60 Marks:**

  Question paper format:

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **Three questions** needs to be answered.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173115	Analysis of Algorithm Lab	--	2	-	--	2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2173115	Analysis of Algorithm Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce the methods of designing and analyzing algorithms
2. Design and implement efficient algorithms for a specified application
3. Strengthen the ability to identify and apply the suitable algorithm for the given real-world problem.
4. Analyze worst-case running time of algorithms and understand fundamental algorithmic problems

Lab Outcomes: At the end of the course, the students will be able to

1. Implement the algorithms using different approaches.
2. Analyze the complexities of various algorithms.
3. Compare the complexity of the algorithms for specific problem.

Prerequisite: Basic knowledge of programming and data structure

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic knowledge of programming and data structure		
I	Introduction	Performance analysis- Master Method, space, and time complexity Growth of function, Big-Oh, Omega Theta notation Mathematical background for algorithm analysis. Analysis of selection sort, insertion sort.	2	**LO1, LO2, LO3**
II	Divide and Conquer Approach	General method, Merge sort, Quick sort, Analysis of Binary search. **Self-learning Topics:** Finding minimum and maximum algorithms and their Analysis, Strassen's Algorithm	2	**LO1, LO2, LO3**
III	Greedy Method Approach	General Method, Single source shortest path: Dijkstra AlgorithmFractional Knapsack problem, Minimum cost spanning trees: Kruskal and Prim's algorithms **Self-learning Topics:** Job sequencing with deadlines	2	**LO1, LO2, LO3**

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IV	Dynamic Programming Approach	General Method, Multistage graphs All pair shortest path: Floyd Warshall Algorithm, 0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence **Self-learning Topics:** Bellman Ford Algorithm	2	**LO1, LO2, LO3**
V	Backtracking and Branch and bound	General Method, Backtracking: N-queen problem, Sum of subsets,Graph coloring Branch and Bound: Travelling Salesperson Problem, 15 Puzzle problem	2	**LO1, LO2, LO3**
VI	String Matching Algorithms	The Naïve string-matching algorithm, The Rabin Karp algorithm, The Knuth-Morris-Pratt algorithm	2	**LO1, LO2, LO3**

Text Books:

1. T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005.
2. Ellis Horowitz, Sartaj Sahni, S. Rajsekaran. "Fundamentals of computer algorithms" University Press.

Reference Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw- Hill Edition.
2. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI

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Online Resources:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/106/106/106106131/
2.	https://swayam.gov.in/nd1_noc19_cs47/preview
3.	https://www.coursera.org/specializations/algorithms
4.	https://www.mooc-list.com/tags/algorithms

Sr No	List of Assignments / Tutorials	Hrs
01	Assignment covers the topics from first three units limited to three Questions	2
02	Assignment covers the topics from Last three units limited to three Questions	2

Suggested list of Experiments.

Sr No	Title of Experiments	Hrs
01	Experiment based on common mathematical functions.(Selection sort, Insertion sort)	2
02	Experiment based on divide and conquers approach. (Merge sort, Quick sort, Binary search)	2
03	Experiment based on greedy approach.(Single source shortest path- Dijkstra Fractional Knapsack problem, Minimum cost spanning trees-Kruskal and Prim's algorithm)	2
04	Experiment using dynamic programming approach (All pair shortest path- Floyd Warshall, 0/1 knapsack)	2
05	Travelling salesperson problem Longest common subsequence	2
06	Experiment based on graph Algorithms (BFS, DFS , etc)	2
07	Experiment using Backtracking strategy. (N-queen problem, Sum of subsets, Graph coloring)	2
08	Experiment using branch and bound strategy.	2
09	Experiment based on string matching/amortized analysis (The Naïve string-matching Algorithms , The Rabin Karp algorithm, The Knuth-Morris-Pratt algorithm.	2
10	Implementation Min-Max Algorithm	2
11	Implementation of Job Sequencing with deadlines.	2
12	Implementation of Bellman Ford Algorithm using Dynamic programming	2

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173116	Computer Organization & Architecture Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2173116	Computer Organization & Architecture Lab	--	--	--	--	25	25	50

Prerequisite: C/C++ Programming Language.	
Lab Objectives:	
1	To study and learn assembler and using its utilities.(MASM)
2	To write assembly language programs.
3	To perform various ALU operations using assembly language programs.
4	To enable and use graphical mode in assembly language programs.
5	To implement arithmetics operations using algorithms.
6	To implement cache memory mapping techniques.

Lab Outcomes: At the end of the course, student will be able to	
1	To install the MASM.
2	Write assembly language programs.
3	Utilised various utility of INT 21H interrupts.
4	Utilised various utility of INT 10H interrupts.
5	Simulate various algorithms.
6	Simulate varus cache memory mapping techniques.

Suggested List of Experiments:

Sr. No	Title of Experiments	LO
1	Installation and configure: DOS, MASM, Debug and X86 Mode	1
2	Implementation of various ALU operations (ADD, SUB, MUL, DIV, AND, OR, XOR, NOT) through assembly language programming for 8086 using MASM and Debug.	2
3	Implementation of number conversion (HEX to BCD, ASCII to BCD, BCD to ASCII) using MASM.	2
4	Implementation of two 8-bit BCD addition with accepting input from keyboard and displaying output on monitor using INT 21H interrupts.	3
5	Implement various String Operations in 8086 through the utilities provided by DOS and BIOS interrupts (MASM)	2
6	Block Transfer and Block Exchange using Index Registers.	2
7	Drawing basic shapes like rectangle, triangle, etc. using BIOS services [Use C/MASM]	4
8	Design Password Detection Application using BIOS and DOS interrupts along with 8086	2

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	instructions.	
9	Implement file operations [DOS Interrupts in C/MASM]	2
10	Implement I/O interfacing using inbuilt speakers of IBM PC	2
11	Implementation of cursor activity like hiding cursor and changing it to box size using INT 10H interrupts.	4
12	Implement Booth's Multiplication Algorithm	5
13	Implement Division Algorithm (Non-Restoring and/or Restoring)	5
14	Implementation of Mapping techniques of Cache memory	6
15	Displaying 8086 processor's Flag register content on monitor.	2
16	Designing 4X4 memory using 1X1 memory chips. Use COA virtual lab by IIT Kharagpur.	

Text Books:

Sr. No	Title	Edition	Authors	Publisher	Year
1	Computer Organization	5th	Carl Hamacher, Zvonko Vranesic and Safwat Zaky	Tata McGraw-Hill	2002
2	Computer Architecture and Organization	3rd	John P. Hayes	Tata McGraw-Hill	2012
3	Computer Organization and Architecture: Designing for Performance	8th	William Stallings	Pearson	2010
4	Microprocessor and Interfacing: Programming & Hardware	3rd	Douglas V Hall	Tata-McGraw Hill	2017

Reference Books:

Sr. No	Title	Edition	Authors	Publisher	Year
1	Structured Computer Organization	6th	Andrew S. Tanenbaum	Pearson	2012
2	Microcomputer System The 8086/8088 family	2nd	Liu and Gibson	Pearson	2015
3	Computer Architecture and Organization: Design Principles and Applications	2nd	B. Govindarajulu	McGraw Hill	Paperback-2017
4	Advance Computer Architecture: Parallelism, Scalability, Programmability	3rd	Kai Hwang	Tata-McGraw Hill	2017
5	Programmer's reference Manual for IBM Personal Computers	1st	Steven Armburst	Tata-McGraw Hill	

Online References:

Sr. No.	Website Name
1.	https://www.classcentral.com/course/swayam-computer-organization-and-architecture-a-pedagogical-aspect-9824
2.	https://nptel.ac.in/courses/106/103/106103068/
3.	https://www.coursera.org/learn/comparch
4	https://www.edx.org/learn/computer-architecture

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5	http://cse10-iitkgp.virtual-labs.ac.in/

Sr No	Suggested List of Assignments
1.	Number conversion from one base to another and addition and subtraction on converted numbers.
2.	Numerical on Booth's Algorithm and on Restoring and Non restoring algorithm. IEEE 754 conversion.
3.	Numerical on Cache memory mapping. Cache coherency and resolution methods.
4.	Different techniques for designing control unit of computer.
5.	Different data transfer techniques and bus arbitration.
6.	Pipeline and pipeline hazards.
7.	Flynn's classification scheme.
8.	Memory interleaving and associative memory.

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the theory and practical syllabus.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2174111	Computational Theory	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	T1 +T2					
2174111	Computational Theory	20	20	40	60	2	--	--	100

Course Objectives:	1) To acquire conceptual knowledge of grammar and languages. 2) To understand the relation between Regular Language and Finite Automata. 3) To understand the language hierarchy, CFG and CFL. 4) To design a PDA equivalent to a given context-free grammar/language. 5) To learn the principles of computation by designing a Turing Machine 6) To infer the knowledge of undecidable and NP class problems.
Course Outcomes:	Upon completion of the course, the learners will be able to: 1) Use TCS theory to design regular expressions that represent regular languages. 2) Design, analyze, and optimize Finite Automata for language recognition. 3) Design Regular and Context Free Grammars and learn to simplify the CFG. 4) Design PDA for a given context-free grammar or language and enumerate its applications. 5) Design Turing machines as generators, deciders, and acceptors for various computational tasks. 6) Understand and utilize problem classification techniques for problem analysis.

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Detailed Contents:

Sr. No.	Name of Module	Detailed Content	Hrs	CO Mapping
0	Prerequisite	Basic Mathematical Fundamentals: Sets, Logic, Relations, Functions, Discrete Structures.		
I	**Basics Concepts and Regular Languages**	Importance of TCS, Alphabets, Strings, Languages	**1**	**CO1**
		Regular operations, Regular Expression, Arden's theorem, RE Applications, Regular Language, Closure properties. Decision properties of RLs, Pumping lemma for RLs.	**5**	**CO1**
		Self-learning Topics: RE in text search and replace, Application of Regular Languages in Compiler Design, Text Processing, and Natural Language Processing (NLP).		
II	**Finite Automata**	Finite Automata (FA) & Finite State machine (FSM).	**1**	**CO2**
		Deterministic Finite Automata (DFA) and Nondeterministic Finite Automata (NFA): Definitions, transition diagrams and Language recognizers, Equivalence between NFA with and ϵ- transitions, NFA to DFA Conversion, Minimization of DFA, FSM with output: Moore and Mealy machines, Applications and limitations of FA.	**6**	**CO2**

		Self-learning Topics: State Elimination Method for converting FA to RE, Minimization of DFA using Equivalence Theorem, Conversion of Moore to Mealy & Mealy to Moore machine.		
III	**Regular and Context Free Grammars**	Grammars and Chomsky Hierarchy	**1**	**CO3**
		Regular Grammar (RG), Equivalence of Left and Right linear grammar, Equivalence of RG and FA.	**2**	**CO3**
		Context Free Grammars (CFG) Definition, Sentential forms, Leftmost and Rightmost derivations, Parse tree, Ambiguity, **Simplification of CFG:** Eliminating unit productions, useless production, useless symbols, and Є-productions, **Normal Forms:** Chomsky Normal Form (CNF) and Greibach Normal Form (GNF), Context Free language (CFL) - Application: Parser, Markup languages; Pumping lemma, Closure properties.	**6**	**CO3**
		Self-learning Topics: Left Recursion and Its Elimination, Applications of CFGs in XML Parsing, and Natural Language Processing (NLP).		
IV	**Pushdown Automata (PDA)**	Definition, Language of PDA, PDA as generator, decider and acceptor of CFG, Deterministic PDA , Non-Deterministic PDA, Equivalence of PDA and CFG, Application of PDA.	**5**	**CO4**
		Self-learning Topics: Parsing & PDA: Top-Down Parsing, Bottom-up Parsing, Closure properties and Deterministic PDA.		
V	**Turing Machine (TM)**	Definition, Design of TM as generator, decider and acceptor, Variants of TM: Multitrack, Multitape, Universal TM, Applications, Power and Limitations of TMs.	**7**	**CO5**
		Self-learning Topics: Algorithms using Turing Machine, The Model of Linear Bounded Automata		
VI	**Decidability and Computability**	Decidability and Undecidability, Recursive and Recursively Enumerable Language, Halting Problem, Rice's Theorem, Post Correspondence Problem.	**5**	**CO6**
		Self-learning Topics: NP Completeness of the SAT Problem, A Restricted Satisfiability Problem		

Text Books:	1) John E. Hopcroft, Rajeev Motwani, Jeffery D. Ullman, Introduction to Automata Theory Language and Computation, 3rd Edition, Pearson Education, 2008. 2) Michael Sipser, Theory of Computation, 3rd Edition, Cengage learning. 2013. 3) Vivek Kulkarni, Theory of Computation, Illustrated Edition, Oxford University Press, (12 April 2013) India.
References Books :	1) J. C. Martin, Introduction to Languages and the Theory of Computation, 4th Edition, Tata McGraw Hill Publication, 2013. 2) Kavi Mahesh, Theory of Computation: A Problem-Solving Approach, Kindle Edition, Wiley-India, 2011.

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Online References:	1) https://www.jflap.org/ 2) https://nptel.ac.in/courses/106104028 3) https://nptel.ac.in/courses/106104148
Internal Assessment (IA) :	Internal Assessment will consist of **Two** Compulsory IA Tests and shall be conducted for Total 40 Marks including 02 Tests of 20 marks each. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.
Question paper format:	• Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus** • **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules) • A total of **Three questions** needs to be answered

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2174112	Database Management System	3	2	-	3	1	-	4

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg.					
2174112	Database Management System	20	20	40	60	2	--	--	100

Rationale:

Today's data-driven world, Database Management Systems (DBMS) are essential for efficiently storing, managing, and analyzing data. This course equips students with foundational concepts and practical skills to design and implement robust data-driven solutions across diverse domains.

Sr. No.	Course Objectives:
1	To Understand the fundamentals of a database systems
2	Develop entity relationship data model /EER and its mapping to relational model
3	Learn relational algebra and Formulate SQL queries.
4	Apply normalization techniques to normalize the database
5	Understand concept of transaction, concurrency control and recovery techniques
6	Explore and understand recent databases and their application

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Sr No	Course Outcomes	BL
CO1	Understand concepts of DBMS and design ER/EER diagram for real world application.	L2, L3
CO2	Apply mapping rules to construct relational model from data model and formulate relational algebra queries.	L3
CO3	Apply SQL queries for database operations.	L3
CO4	Analyze and apply normalization techniques to relational database design.	L3, L4
CO5	Understand transaction, concurrency and recovery techniques to analyze conflicts in multiple transactions.	L2
CO6	Understand recent databases.	L2

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic knowledge of Data structure, Fundamentals of computer system		
I	**Introduction to Database and Data Modeling**	**Introduction:** Definitions and application, Characteristics of databases, DBMS architecture, ACID Properties **The Entity-Relationship (ER) Model**: Entity types: Weak and strong entity sets, Entity sets, Types of Attributes, Keys, Relationship constraints: Cardinality and Participation, Extended Entity-Relationship (EER) Model:	**08**	**CO1**

		Generalization, Specialization and Aggregation **Self-learning Topics:** Design an ER model for any real time case study.		
II	**Relational Model and Relational Algebra**	Introduction to the Relational Model, relational schema and concept of keys. Mapping the ER and EER Model to the Relational Model, Relational Algebra- operators (Selection(σ),Projection(π),Union(∪),Difference (−),CartesianProduct(×),Join(⋈), Intersection (∩),Rename (ρ)), Relational Algebra Queries **Self-learning Topics:** Practice writing queries to perform common database tasks (e.g., selecting data, joining tables	**05**	**CO2**
III	**Structured Query Language (SQL)**	Overview of SQL, Data Definition Commands, Integrity constraints: key constraints, Domain Constraints, Referential integrity, check constraints, Data Manipulation commands, Data Control commands, Transaction Control Commands. aggregate function-group by, having, order by, joins, Nested and complex queries, Views in SQL, Set and string operations, Triggers, Introduction to Pl/SQL Block Structure **Self-learning Topics:** LeetCode (SQL practice problems), HackerRank (SQL challenges)	**10**	**CO3**
IV	**Database Normalization**	Pitfalls in relational database designs, Concept of normalization, Function Dependencies, FD closure, First Normal Form, 2NF, 3NF, BCNF, 4NF. **Self-learning Topics:** Consider any real time application and normalization upto 3NF/BCNF	**5**	**CO4**
V	**Transaction Management and Concurrency Control**	Transaction concept, Transaction states, Concurrent Executions, Serializability-Conflict and View, Concurrency Control: Lock-based, Timestamp-based protocols, Recovery System: log-based recovery, Introduction to Deadlock handling **Self-learning Topics:** SQL challenges related to transactions and concurrency	**7**	**CO5**
VI	**Introduction to Modern databases**	Recent trends in the industry, Introduction of Cloud Database, Introduction of Distributed Database, Introduction to NOSQL Database and Object-Oriented Databases **Self-learning Topics:** Learn about emerging database technologies. Explore different NoSQL types. Learn how object-oriented programming concepts like objects and inheritance are applied to database management systems.	**4**	**CO6**

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Text Books:

1. Elmasri and Navathe, Fundamentals of Database Systems, 7th Edition, Pearson Education
2. Korth, Slberchatz, Sudarshan, Database System Concepts, 7th Edition, McGraw Hill
3. Raghu Ramkrishnan and Johannes Gehrke, Database Management Systems, TMH
4. RajkumarBuyya, Christian Vecchiola, S ThamaraiSelvi, "Mastering Cloud Computing", Tata McGraw-Hill Education

Reference Books:

1. Peter Rob and Carlos Coronel, Database Systems Design, Implementation and Management, Thomson Learning, 5th Edition.
2. Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g, Black Book, Dreamtech Press.
3. G. K. Gupta, Database Management Systems, McGraw Hill, 2012

Online References:

Sr. No.	Website Name
1.	NPTEL Lecture Series: Database Management system By Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay | IIT Kharagpur
2.	https://www.classcentral.com/course/swayam-database-management-system-9914
3.	https://www.mooc-list.com/tags/dbms
4.	W3Schools: SQL tutorials

Internal Assessment (IA) for 40 marks:

IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

End Semester Internal Examination for 40 marks:

Question paper format:

- Question Paper will comprise of a total of **six questions each carrying 20 marksQ.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **Three questions** needs to be answered.

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
2174113	**Operating System**	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Pract. /Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Total				
2174113	**Operating System**	20	20	40	60	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	To understand the basic concepts of Operating System, its functions and services.
2	To introduce the concept of a process and its management like transition, scheduling, etc.
3	To understand basic concepts related to Inter-process Communication (IPC) like mutual exclusion, deadlock, etc. and role of an Operating System in IPC.
4	To understand the concepts and implementation of memory management policies and virtual memory.
5	To understand functions of Operating System for storage management and device management.
6	To study the need and fundamentals of special-purpose operating system with the advent of new emerging technologies.

Course Outcomes:

Sr. No.	Course Outcomes
1	Define the basic concepts of Operating System, its operations and services.
2	Explain the process management policies and describe the scheduling of processes by the Operating System.
3	Apply synchronization primitives to address process coordination and demonstrate the occurrence of deadlock conditions.
4	Analyze memory allocation and management functions of Operating System.
5	Evaluate the effectiveness of the services provided by the Operating System for File and I/O Management, considering their impact on overall system performance.
6	Design a framework to compare and optimize the functions of various special-purpose Operating Systems for specific application requirements.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
I	Fundamentals of Operating System	**Introduction of Operating Systems:** System Boot, Objectives of Operating System Functions of Operating System, Operating System Structure and Operations, Operating System Services, Multiprogramming, Multitasking, Multithreading, Types of Operating System, Types of System Calls.	**03**	CO1

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		Self-learning Topics: Study of various Operating System Architecture like IoT, Android.		
II	Process Management	Basic Concepts of Process: Process State Transition Model, Operations, Process Control Block**,** Context Switching; Introduction to Threads, Types of Threads, Thread Models**,** Basic Concepts of Scheduling, Types of Schedulers, Type of scheduling algorithms: Preemptive and non preemptive (FCFS, SJF, Priority and Round Robin) **Self-learning Topics:** Real-time Scheduling algorithms and applications.	**06**	CO2
III	Process Synchronization and Deadlock Management	Basic Concepts of Inter-process Communication and Synchronization, Race Condition, Critical Section Problem ,Peterson's Solution, Process Synchronization, Hardware and Semaphores, Producer Consumer Problem. Deadlocks Management: System Model, Deadlock Characterization, Deadlock Prevention, Deadlock Avoidance: Bankers algorithm, Deadlock Detection and Recovery. **Self-learning Topics:** Study a real time case study for Deadlock detection and recovery. Overview of security mechanism in OS.	**10**	CO3
IV	Memory Management	Basic Concepts of Memory Management: Swapping, Memory Allocation strategy, Paging, Structure of Page Table, Segmentation, TLB. Basic Concepts of Virtual Memory, Demand Paging, Copy-on Write, Page Replacement Algorithms, Thrashing. **Self-learning Topics:** Memory Management of IoT, Android Operating System.	**09**	CO4
V	File and IO Management	File Management: Basic Concepts of File System, File Access Methods, Directory Structure, File-System implementation, Allocation Methods, Overview of Mass-Storage Structure, I/O devices, Organization of the I/O Function, Disk Organization, I/O Management and Disk Scheduling: FCFS, SSTF, SCAN, C-SCAN, LOOK, C-LOOK. **Self-learning Topics:** File System for Linux and Windows, Features of I/O facility for different OS.	**07**	CO5
VI	Special-purpose Operating Systems	Open-source and Proprietary Operating System, Fundamentals of Distributed Operating System, Network Operating System, Architecture and functions: Cloud Operating System, Real-Time Operating System, Mobile Operating System. **Self-learning Topics:** Case Study on any one Special-purpose Operating Systems.	**04**	CO6

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Text Books:

1. A. Silberschatz, P. Galvin, G. Gagne, Operating System Concepts, 10th ed., Wiley, 2018.
2. W. Stallings, Operating Systems: Internal and Design Principles, 9th ed., Pearson, 2018.
3. A. Tanenbaum, Modern Operating Systems, Pearson, 4th ed., 2015.

Reference Books:

1. Achyut Godbole and Atul Kahate, Operating Systems, McGraw Hill Education, 3rdEdition
2. N. Chauhan, Principles of Operating Systems, 1st ed., Oxford University Press, 2014.
3. A. Tanenbaum and A. Woodhull, Operating System Design and Implementation, 3rd ed., Pearson.
4. R. Arpaci-Dusseau and A. Arpaci-Dusseau, Operating Systems: Three Easy Pieces, CreateSpace Independent Publishing Platform, 1st ed., 2018.

Online References:

1. https://www.nptel.ac.in
2. https://swayam.gov.in
3. https://www.coursera.org/

Assessment:

Internal Assessment (IA) for 40 marks:

IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

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End Semester Internal Examination for 40 marks:

Question paper format:

- Question Paper will comprise of a total of **six questions each carrying 20 marksQ.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **Three questions** needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2174114	Database Management System Lab	2	-	-	2	-	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2174114	Database Management System Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To explore database management system concepts and their application
2. To learn major components of DBMS (DDL, DML, DCL, TCL)
3. Understand the use of Structured Query Language (SQL) and learn SQL syntax.
4. To understand the different database constraints and their usage.
5. Understand the needs of database processing transaction handling
6. Learn techniques for controlling and managing concurrent data access

Lab Outcomes: On successful completion of course, learner will be able to:

1. Design ER and EER diagram for the real-life problem with software tool.
2. Create and update database and tables with different DDL and DML statements.
3. Apply /Add integrity constraints and able to provide security to data.
4. Implement and execute Complex queries.
5. Apply triggers and procedures for specific module/task
6. Apply concurrent transactions and implement through practical examples

Prerequisite:

- The below suggested experiments needs to be performed by a group of **2 students. (Mini 10 Experiments)**
- Suggestion: Select any database management system problem statement and try to execute all experiments based on the same topic

Module	Suggested List of experiments	Hours
1	Identify the case study and detail statement of problem. Design an Entity-Relationship (ER) / Extended Entity-Relationship (EER) Model.	02
2	Mapping ER/EER to Relational schema model.	02
3	Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System	02
4	Apply DML Commands for the specified system	02
5	Perform Simple queries, string manipulation operations and aggregate functions.	02
6	Implement various Join operations.	02

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7	Perform Nested and Complex queries	04
8	Perform DCL and TCL commands	02
9	Implement procedure and functions	02
10	Implementation of Views and Triggers.	02
11	Implementation and demonstration of Transaction and Concurrency control techniques using locks.	02
12	Mini project (Design simple GUI and Backend Connectivity)	02

Assessment:
Term Work: Term Work shall consist of at **least 10 to 12 practical** based on the above list.
Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment with Attendance) + 5 Marks (**very basic Mini Proj- as mention in Exp. No 12)** + 5 Marks (Assignment)
Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus**.**

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2174115	Operating System Lab	2	-	-	2	-	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2174115	Operating System Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To gain practical experience with designing and implementing concepts of operating systems such as system calls, CPU scheduling, process management, memory management, file systems and deadlock handling using C language in Linux environment.
2. To familiarize students with the architecture of Linux OS.
3. To provide necessary skills for developing and debugging programs in Linux environment.
4. To learn programmatically to implement simple operation system mechanisms

Suggested List of Experiments.

Sr No	Suggested List of Experiments	Hrs
01	Explore usage of basic Linux Commands and system calls for file, directory and process management. For eg: (mkdir, chdir, cat, ls, chown, chmod, chgrp, ps etc. system calls: open, read, write, close, getpid, setpid, getuid, getgid, getegid, geteuid. sort, grep, awk, etc.)"	02
02	Write shell scripts to do the following: a. Display OS version, release number, kernel version b. Display top 10 processes in descending order c. Display processes with highest memory usage. d. Display current logged in user and log name. e. Display current shell, home directory, operating system type, current path setting, current working directory.	02
03	Implement any one basic commands of linux like ls, cp, mv and others using kernel APIs.	02
04	Create a child process in Linux using the fork system call. From the child process obtain the process ID of both child and parent by using getpid and getppid system call.	02
05	a. Write a program to demonstrate the concept of non-preemptive scheduling algorithms (any one).	02
06	Write a program to demonstrate the concept of preemptive scheduling algorithms (any one)	02
07	Write a C program to implement solution of Producer consumer problem through Semaphore	02
08	Write a program to demonstrate the concept of deadlock avoidance through Banker's Algorithm	02
09	Write a program to demonstrate the concept of MVT and MFT memory management techniques	02

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10	Write a program to demonstrate the concept of dynamic partitioning placement algorithms i.e. Best Fit, First Fit, Worst-Fit etc.	02
11	Write a program to demonstrate the concept of demand paging for simulation of Virtual Memory implementation	02
12	Write a program in C demonstrate the concept of page replacement policies for handling page faults eg: FIFO, LRU etc.	02
13	Write a C program to simulate File allocation strategies typically sequential, indexed and linked files	02
14	Write a C program to simulate file organization of multi-level directory structure.	02
15	Write a program in C to do disk scheduling - FCFS, SCAN, C-SCAN	02
16	Understand the basics of distributed systems through simple file sharing. Set up a network of two or more computers (or virtual machines) on the same network. Configure a shared folder using Samba on Linux (or Windows shared folders) so both systems can access files. Transfer files between the machines and observe the performance of data sharing.	02
17	Get hands-on experience with mobile OS development. Develop a basic app using Android Studio (Java/Kotlin) or Xcode (Swift). Explore Android/iOS permissions by requesting basic access like camera or location. Deploy the app on an emulator or physical device.	02

Note: Any 3 questions from assignment 1 and assignment 2 but should cover all CO's

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Sr No	Suggested List of Assignments / Tutorials	Co mapped
	Assignment 1	
01	System Boot Process and OS Initialization: Research and document the system boot process on two different platforms: Windows and Linux.	CO1
02	Exploring Operating System Services : Research and create a detailed report or presentation on the various services provided by an operating system.	CO1
03	Process State Transition Model and Process Control Block (PCB): Explore the structure and role of the Process Control Block (PCB) in modern operating systems. Research how the process state transition model works in various OS architectures (e.g., Unix, Linux, Windows).	CO2
04	Types of Threads and Thread Models: A Comparative Study of Thread Models and Their Applications in Multi-core Systems. Analyze different thread models (User-level, Kernel-level, Hybrid) and their performance in real-world applications.	CO2
05	Inter-process Communication and Synchronization: Explore different inter-process communication (IPC) mechanisms used in operating systems, such as message passing, shared memory, and pipes. Compare their performance, scalability, and use cases in modern OS environments.	CO3
06	Operating System Security: Investigate and prepare a report on common security vulnerabilities in modern operating systems (e.g., buffer overflow, privilege escalation) and propose measures to mitigate these vulnerabilities.	CO3
	Assignment 2	
01	Swapping: Compare and contrast how concept of swapping works in modern OS (e.g., Linux, Windows) versus older systems. Include the performance trade-offs involved in swapping and how it impacts system responsiveness and resource utilization.	CO4
02	Structure of Page Table :Explore the structure of page tables in modern operating systems, and compare different schemes such as hierarchical page tables, inverted page tables, and hashed page tables. Investigate the benefits and limitations of each.	CO4
03	Basic Concepts of File System: Focus on the role of the file system in managing files, directories, and metadata. Compare different types of file systems, such as FAT, NTFS, ext4, and APFS, and explain how each handles file organization, access, and storage.	CO5

04	Disk Organization : Study the physical and logical organization of disks, including tracks, sectors, cylinders, and the role of the disk controller. Explain how the OS maps logical block addresses (LBA) to physical addresses	CO5
05	Open-source vs Proprietary Operating Systems : Compare and contrast open-source operating systems (e.g., Linux, FreeBSD) and proprietary operating systems (e.g., Windows, macOS).	CO6
06	Real-Time Operating System (RTOS): explain the key characteristics of a Real-Time Operating System (RTOS), focusing on aspects like deterministic behavior, task scheduling, and real-time deadlines.	CO6

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

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Vertical – 4

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2174411	**Mini Project**	--	4	--	--	2	--	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test 1	Test 2	Avg. of 2 Tests				
2174411	**Mini Project**	--	--	--	--	50	25	75

Objectives	
1	To acquaint with the process of identifying the needs and converting it into the problem.
2	To familiarize the process of solving the problem in a group.
3	To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4	To inculcate the process of self-learning and research.
Outcome: Learner will be able to…	
1	Identify problems based on societal /research needs.
2	Apply Knowledge and skill to solve societal problems in a group.
3	Develop interpersonal skills to work as member of a group or leader.
4	Draw the proper inferences from available results through theoretical/ experimental/simulations.
5	Analyse the impact of solutions in societal and environmental context for sustainable development.
6	Use standard norms of engineering practices
7	Excel in written and oral communication.
8	Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9	Demonstrate project management principles during project work.
Guidelines for Mini Project	
1	Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.

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2	Interdisciplinary mini project is also permitted.
3	Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
4	Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
5	A logbook to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6	Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
7	Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
8	Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
9	The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
10	With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Project.

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Term Work		
The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in the semester.		
In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.		
Distribution of Term work marks shall be as below:		**Marks**
1.	Marks awarded by guide/supervisor based on logbook	10
2.	Marks awarded by review committee (Average of Review 1 & Review 2)	10
	Mini-Project Review-1	
	a. Identification of Problem	2
	b. Requirement analysis and Feasibility of the proposed work	2
	c. Literature Review	2
	d. Objectives of the proposed work	2
	e. Methodology of the proposed work	2
	Total Marks	10

	Mini-Project Review-2	
	a. Planning of project work and team structure	2
	b. Design Methodology	2
	c. Conceptual and Technical Demonstration	2
	d. Presentation: Oral delivery, contact with audience, slides, timing	2
	e. Quality of answers	2
	Total Marks	10
3	**Quality of Project report**	**5**

Review / progress monitoring committee may consider following points for the assessment	
1	Students group shall complete project in all aspects including, · Identification of need/problem · Proposed final solution · Procurement of components/systems · Building prototype and testing
2	Two reviews will be conducted for continuous assessment, · First shall be for finalization of problem and proposed solution · Second shall be for implementation and testing of solution.
Assessment criteria of Mini Project.	
Mini Project shall be assessed based on following criteria;	
1	Quality of survey/ need identification
2	Clarity of Problem definition based on need.
3	Innovativeness in solutions
4	Feasibility of proposed problem solutions and selection of best solution
5	Cost effectiveness
6	Societal impact
7	Innovativeness
8	Cost effectiveness and Societal impact
9	Full functioning of working model as per stated requirements
10	Effective use of skill sets
11	Effective use of standard engineering norms
12	Contribution of an individual's as member or leader

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13	Clarity in written and oral communication	

Guidelines for Assessment of Mini Project Practical/Oral Examination:

1	Report should be prepared as per the mentioned guidelines (Preferred in LaTex).	5
2	Mini-Project shall be assessed through a presentation and demonstration of the working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by the head of Institution. Project presentation and demonstration to be evaluated w.r.t following parameters.	
	a. Identification of Problem and Literature review	4
	b. Problem Statement and Objective of the Proposed work	4
	c. Design Methodology	4
	d. Implementation	4
	Total marks	**16**
3	Students shall be motivated to publish a paper based on the work in Conferences/ students competitions e.t.c	4
	Total marks	**25**

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References to get Project ideas:

- https://www.guvi.in/blog/top-mini-project-ideas-for-college-students/
- https://www.geeksforgeeks.org/project-idea-college-network/?ref=ml_lbp
- https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/ai-project-ideas
- https://roadmap.sh/backend/project-ideas
- https://webflow.com/blog/website-ideas
- https://gist.github.com/MWins/41c6fec2122dd47fdfaca31924647499
- https://www.projectpro.io/article/artificial-intelligence-project-ideas/461
- https://github.com/The-Cool-Coders/Project-Ideas-And-Resources
- https://nevonprojects.com/project-ideas/software-project-ideas/
- https://roadmap.sh/projects

Vertical – 5

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993511	Entrepreneurship Development	--	2*+2	-	-	2*+2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IAT-I	IAT-II	IAT-I + IAT-II				
2993511	Entrepreneurship Development	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce students to entrepreneurship concepts and startup development.
2. To develop business idea generation, validation, and business model preparation.
3. To provide hands-on experience in market research, financial planning, and business pitching.
4. To enhance problem-solving and decision-making skills in entrepreneurial ventures.
5. To familiarize students with government schemes and support systems for entrepreneurs.
6. To develop communication and presentation skills required for business pitching.

Lab Outcomes:

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

1. Understand the fundamental concepts of entrepreneurship and business models.
2. Conduct market research and develop business plans.
3. Utilize financial planning and cost analysis for startups.
4. Apply entrepreneurial skills to identify and solve business challenges.
5. Develop prototypes using open-source software for business operations.
6. Pitch business ideas effectively with structured presentations.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Fundamentals of communication and leadership skills.	01	--
I	**Introduction to Entrepreneurship**	Definition, Characteristics, and Types of Entrepreneurs. Entrepreneurial Motivation and Traits. Start-up Ecosystem in India. Challenges in Entrepreneurship	02	LO1
II	**Business Idea Generation & Validation**	Ideation Techniques: Design Thinking, Brainstorming, Mind Mapping. Business Model Canvas (BMC). Market Research & Customer	04	LO2

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		Validation. Minimum Viable Product (MVP) Concept.		
III	**Business Planning & Strategy**	Writing a Business Plan. SWOT Analysis and Competitive Analysis. Financial Planning and Budgeting. Risk Assessment and Management	04	LO3
IV	**Funding and Legal Framework**	Sources of Funding: Bootstrapping, Angel Investors, Venture Capital Government Schemes & Start-up India Initiatives. Business Registration & Legal Formalities. Intellectual Property Rights (IPR) & Patents	05	LO4
V	**Marketing & Digital Presence**	Branding and Digital Marketing. Social Media Marketing & SEO. Customer Relationship Management (CRM). E-commerce & Online Business Models	05	LO5
VI	**Business Pitching & Prototype Development**	Pitch Deck Preparation & Presentation Techniques. Prototyping with Open-source Tools. Elevator Pitch & Investor Pitch. Case Studies of Successful Start-ups	05	LO6

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Text Books:

1. "Entrepreneurship Development and Small Business Enterprises" – Poornima M. Charantimath, Pearson, 3rd Edition, 2021.
2. "Innovation and Entrepreneurship" – Peter F. Drucker, Harper Business, Reprint Edition, 2019.
3. "Startup and Entrepreneurship: A Practical Guide" – Rajeev Roy, Oxford University Press, 2022.
4. "Essentials of Entrepreneurship and Small Business Management" – Norman Scarborough, Pearson, 9th Edition, 2021.
5. "The Lean Startup" – Eric Ries, Crown Publishing, 2018.

References:

1. "Disciplined Entrepreneurship: 24 Steps to a Successful Startup" – Bill Aulet, MIT Press, 2017.
2. "Zero to One: Notes on Startups, or How to Build the Future" – Peter Thiel, 2014.
3. "The $100 Startup" – Chris Guillebeau, Crown Business, 2019.
4. "Business Model Generation" – Alexander Osterwalder & Yves Pigneur, Wiley, 2020.
5. "Blue Ocean Strategy" – W. Chan Kim & Renée Mauborgne, Harvard Business Review Press, 2019.

Online Resources:

Website Name
1. **Startup India Portal** – https://www.startupindia.gov.in 2. **MIT OpenCourseWare – Entrepreneurship** – https://ocw.mit.edu/courses/sloan-school-of-management/ 3. **Coursera – Entrepreneurship Specialization** – https://www.coursera.org/specializations/entrepreneurship 4. **Harvard Business Review – Entrepreneurship Articles** – https://hbr.org/topic/entrepreneurship 5. **Udemy – Startup & Business Courses** – https://www.udemy.com/courses/business/entrepreneurship/

List of Experiments.

Sr No	List of Experiments	Hrs
01	Business Idea Generation using Mind Mapping.	02
02	Conducting Market Research & Customer Validation.	02
03	Preparing a Business Model Canvas for a Startup Idea.	02
04	Developing a Financial Plan & Break-even Analysis.	02
05	Creating a Website using WordPress/Wix.	02
06	Social Media Marketing Campaign using Open-source Tools.	02
07	Digital Prototyping using Figma/Inkscape.	02
08	Business Pitch Deck Preparation & Presentation.	02
09	Exploring Government Schemes for Startups.	02
10	Legal Compliance & IPR Basics (Case Study).	02

Sr No	List of Assignments / Tutorials	Hrs
01	a. Write a report on any successful entrepreneur and their startup journey. b. Conduct SWOT analysis for a real-life startup.	02
02	Develop a business idea and create a one-page business plan.	02
03	Conduct market research using surveys & present findings.	02
04	Design a simple logo and branding strategy for a startup.	02
05	Create a financial model and cost estimation for a startup.	02
06	Make a case study report on startup failure analysis.	02

List of Open-Source Software
1. Canva – Designing pitch decks, social media posts, and branding materials. 2. Trello / Asana – Project management for startups. 3. GIMP / Inkscape – Graphic design and logo creation. 4. WordPress / Wix – Website development for startups. 5. OpenCart / PrestaShop – E-commerce website setup. 6. Figma – UI/UX design and prototyping. 7. LibreOffice Calc – Financial planning and budgeting. 8. Google Suite (Docs, Sheets, Slides) – Documentation and presentations. 9. Python (Pandas, Flask, Django) – Data analytics and web application development. 10. MailChimp – Email marketing and customer engagement.

Assessment :

Term Work: Term Work shall consist of at least 08 to 10 practicals' based on the above list. Also, Term work Journal must include at least 6 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2993512	Environmental Science for Engineers	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2993512	Environmental Science for Engineers	--	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Rationale:

Most of the engineering branches are offspring of applied sciences, and their practices have a significant impact on the environment. Understanding environmental studies is essential for engineers to develop sustainable solutions, minimize ecological footprints, and promote responsible resource management. This course equips students with the knowledge of ecosystems, biodiversity, pollution control, and environmental laws, enabling them to integrate sustainability into engineering practices.

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Lab Objectives:

1. To understand the scope, importance, and role of environmental studies in public awareness and health.
2. To study different natural resources, their issues, and sustainable conservation.
3. To understand ecosystem types, structures, and functions.
4. To explore biodiversity, its importance, threats, and conservation.
5. To learn about pollution types, causes, effects, and control measures.
6. To understand environmental challenges, sustainability, and ethics.

Lab Outcomes:

1. Explain the significance of environmental studies and the role of IT in environment and health.
2. Describe resource types, associated problems, and conservation methods.
3. Classify ecosystems and explain their role in ecological balance
4. Analyze biodiversity levels and conservation strategies, especially in India.
5. Explain pollution impacts and suggest preventive measures.
6. Discuss environmental issues and propose sustainable solutions.

DETAILED SYLLABUS:

Unit Name	Topic Name	Topic Description	Hours	LO Mapping
I	**The Multidisciplinary Nature of Environmental Studies**	Definition, scope and importance. Need for public awareness, Role of information technology in environment and human health. Human population and the environment: Population growth, variation among nations. Population Explosion- family welfare program. Environment and human health Women and child welfare	**03**	LO1

II	**Natural Resources**	Renewable and non-renewable resources. Natural resources & associated problems: a) Forest resources: b) Water resources: Natural resources & associated problems c) Mineral resources: d) Food resources: e) Energy resources: Role of an individual in conservation of natural resources: f) Equitable use of resources for sustainable lifestyles.	**04**	LO2
III	**Ecosystems**	Concepts of an ecosystem. Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries). Case study on various ecosystems in India.	**05**	LO3
IV	**Biodiversity and its Conservation**	Introduction, Definition, genetic species and ecosystem diversity. Bio-geographical classification of India Value of biodiversity, Consumptive use, productive use, social, ethical, aesthetic and option values, Bio-diversity at global, national, local levels India as a mega diversity nation, Case study on Bio diversity in India.	**05**	LO4
V	**Environmental Pollution Definition**	Causes, effects and control measures of: a) Air pollution b) Water pollution b) Soil pollution. Solid waste management: Causes, effect and control measures of urban and industrial wastes. Role of an individual in prevention of pollution, Case study on Pollution Disaster management: floods, earthquake, cyclone and landslides. Carbon Credits for pollution prevention.	**05**	LO5
VI	**Social Issues and Environment**	From unsustainable to sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Environmental ethics: issues and possible solution. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies. Consumerism and waste products. Environment protection act. Public awareness Case study on Environmental Ethics	**04**	LO6

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Textbooks

1. Environmental Science: Towards a Sustainable Future, G. Tyler Miller and Scott Spoolman, 13th Edition, Cengage Learning 2021
2. Environmental Management: Text and Cases, Bala Krishnamoorthy, 3rd Edition, PHI Learning, Publication Year: 2016
3. Green IT: Concepts, Technologies, and Best Practices, Markus Allemann, Springer 2008

4. Sustainable IT: Slimming Down and Greening Up Your IT Infrastructure, David F. Linthicum, IBM Press 2009
5. Environmental Modelling: Finding Solutions to Environmental Problems, David L. Murray, Cambridge University Press 2016
6. Remote Sensing and Image Interpretation, Thomas M. Lillesand, Ralph W. Kiefer, and Jonathan W. Chipman, 9th Edition, John Wiley & Sons 2020
7. Business Ethics: Concepts and Cases, Manuel Velasquez, Pearson 2012

Reference Books

1. Environmental Law and Policy in India, Shyam Divan and Armin Rosencranz, 2nd Edition, Oxford University Press 2018
2. The International Handbook of Environmental Laws, David Freestone and Jonathon L. Rubin, Edward Elgar Publishing 2000
3. E-Waste Management: Challenges and Opportunities in Developing Countries, Ruediger Kuehr and Ram K. Jain, Springer 2008
4. The E-Waste Handbook: Managing Electronic Waste, Klaus Hieronymi, Ruediger Kuehr, and Ram K. Jain, Earthscan 2009
5. Environmental Ethics: An Introduction, J. Baird Callicott, University of Georgia Press1999

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Online References:

Sr. No.	Website Name
1.	Centre for Science and Environment (CSE), Website: cseindia.org
2.	Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India
3.	CSIR-National Environmental Engineering Research Institute (NEERI)

List of Experiments.

Sr No	List of Experiments	Hrs
01	Study of Environmental Components and Ecosystems.	2
02	Visit and Report on Solid Waste Management Plant.	2
03	Study of Renewable Energy Sources (Solar, Wind, Biogas).	2
04	Analysis of Air and Water Quality Parameters.	2
05	Study of Local Biodiversity and Conservation Methods.	2
06	Awareness Activity on Environmental Issues.	2
07	Rainwater Harvesting System Design	2
08	Case Study on Environmental Pollution & Control Measures.	2
09	Report on Climate Change Impact and Adaptation.	2
10	Study of Environmental Laws and Acts.	2
11	Study of Disaster Management Techniques.	2
12	Report on Role of IT in Environmental Protection.	2

Sr No	List of Assignments / Tutorials	Hrs
01	Prepare a report on Renewable and Non-Renewable Resources.	2
02	Write a case study on Ecosystem Types in India	2
03	Write a report on Biodiversity in India.	2
04	Prepare a report on Pollution Types and Control Measures.	2
05	Prepare a report on Environmental Ethics and Sustainability.	2
06	Prepare a case study report on Global Warming and Climate Change.	2
07	Report on Role of an Individual in Environmental Protection.	2
08	Write a report on Disaster Management Techniques.	2

09	Prepare a report on Environmental Laws and Acts in India.	2
10	Case Study on E-waste Management and Recycling Techniques.	2

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practical's based on the above list. Also, Term work Journal must include at least 8 to 10 assignments.

Term Work Marks: 50 Marks (Total marks) = 20 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report)

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994511	Business Model Development	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2994511	Business Model Development	--	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce a learner to entrepreneurship and its role in economic development.
2. To familiarize a learner with the start-up ecosystem and government initiatives in India.
3. To explain the process of starting a business.
4. To familiarize a learner with the building blocks of a business.
5. To teach a learner to plan their own business with the help of Business Model Canvas.
6. To teach a learner to have financial plan for a business model.

Lab Outcomes:

The learner will be able to:

1. Discuss the role of entrepreneurship in the economic development of a nation and describe the process of starting a business.
2. Describe start-up ecosystems in Indian and global context.
3. Identify different types of business models.
4. Identify customer segments, channels and customer relationship components for a particular business.
5. Identify key activities, key partners and key resources for a particular business.
6. Develop a financial plan for a business with the help of cost structure and revenue model.

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DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	**Prerequisite**	Basic Design Thinking principles	**01**	--
I	**Introduction to Entrepreneurship**	**Introduction to Entrepreneurship**: Definition, the role of entrepreneurship in the economic development, the entrepreneurial process, Women entrepreneurs, Corporate entrepreneurship, Entrepreneurial mindset **Self-learning Topics:** Case studies on Henry Ford: https://www.thehenryford.org/docs/default-source/default-document-library/default-document-library/henryfordandinnovation.pdf?sfvrsn=0 The Tatas: How a Family Built a Business and a Nation by Girish Kuber, April 2019, Harper Business	**04**	**L1, L2**
II	**Entrepreneurship Development**	**Entrepreneurship Development**: Types of business ownerships: Proprietorship, Public and Private Companies, Co-operative businesses, Micro, Small and Medium Enterprises (MSME): Definition and role of MSMEs in economic development	**05**	**L2, L3, L4**

III	**Start-up financing**	**Start-up financing:** Cost and revenue models, Sources of start-up fundings: Angel investors, Venture capitalists, Crowd funding, Government schemes for start-up funding **Self-learning Topics:** Successful business pitching	**04**	**L2, L3, L4, L5**
IV	**Intellectual Property Rights (IPR)**	**Intellectual Property Rights (IPR):** Types of IPR: Patents, trademarks and copyrights, Patent search and analysis, Strategies for IPR protection, Ethics in technology and innovation	**04**	**L2, L3, L4**
V	**Business Model Development**	**Business Model Development:** Types of business models, Value proposition, Customer segments, Customer relationships, Channels, Key partners, Key activities, Key resources, Prototyping and MVP **Self-learning Topics:** The Art of the Start 2.0: The Time-Tested, Battle-Hardened Guide for Anyone Starting Anything by Guy Kawasaki	**04**	**L3, L4, L5, L6**
VI	**Digital Business Management**	**Digital Business Management:** Digital Business models (Subscription, Freemium *etc*), Digital marketing: Search Engine Optimization (SEO), Search Engine Marketing (SEM), Social media and influencer marketing, Disruption and innovation in digital business **Self-learning Topics:** Case study: Airbnb https://www.prismetric.com/airbnb-business-m	**04**	**L2, L3**

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Textbooks:

1. Entrepreneurship: David A. Kirby, McGraw Hill, 2002
2. Harvard Business Review: Entrepreneurs Handbook, HBR Press, 2018
3. Business Model Generation; Alexander Ostlewalder and Yves Pigneur, Strategyzer, 2010
4. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Reference books:

1. Entrepreneurship: New venture creation by David Holt, Prentice Hall of India Pvt. Ltd.
2. E- Business & E– Commerce Management: Strategy, Implementation, Practice – Dave Chaffey, Pearson Education

Online Resources:

Sr. No.	Website Name
1.	Entrepreneurship by Prof. C Bhaktavatsala Rao https://onlinecourses.nptel.ac.in/noc20_mg35/preview
2.	Innovation, Business Models and Entrepreneurship by Prof. Rajat Agrawal, Prof. Vinay Sharma https://onlinecourses.nptel.ac.in/noc21_mg63/preview
3.	Sarasvathy's principles for effectuation https://innovationenglish.sites.ku.dk/model/sarasvathy-effectuation/

List of Experiments.

The lab activities are to be conducted in a group. One group can be formed with 4-5 students. A group has to develop a Business Model Canvas and a digital prototype (Web App/ mobile app). Weekly activities are to be conducted as follows:

Sr No	Lab activities	Hrs
01	Problem identification (Pain points, Market survey)	2
02	Design a digital solution for the problem (Ideation techniques)	2
03	Preparing a business model canvas: Value proposition, Key partners, Key resources, Key activities	2
04	Preparing a business model canvas: Customer segment, Customer relationships and channels	2
05	Preparing a business model canvas: Cost and Revenue structure	2
06	Prototype development: Low fidelity	2
07	Prototype development: Customer feedback	2
08	Prototype development: High fidelity	2
09	Presentation of high-fidelity prototype	2

Sr No	List of Assignments / Tutorials	Hrs
01	Presentation on case study of a failed business model	2
02	Presentation on case study of a woman entrepreneur	2

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Assessment:

Term Work: Term Work shall consist of 09 lab activities based on the above list. Also, Term work journal must include any 2 assignments from the above list.

Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+10 Marks (Report).

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2994512	Design Thinking	--	2*+2	-	--	2*+2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IAT-I	IAT-II	IAT-I+IAT-II					
2994512	Design Thinking	--	--	--	--	--	50	--	50

Note: * Two hours of practical class to be conducted for full class as demo/discussion/theory.

Lab Objectives:

1. To introduce a learner to the principles of Design Thinking.
2. To familiarize a learner with the process (stages) of Design Thinking.
3. To introduce various design thinking tools.
4. Study of the techniques for generation of solutions for a problem.
5. To expose a learner to various case studies of Design Thinking.
6. Create and test a prototype.

Lab Outcomes:

Students will be able to …

1. Compare traditional approach to problem solving with the Design Thinking approach and discuss the principles of Design Thinking
2. Define a user persona using empathy techniques
3. Frame a problem statement using various Design Thinking tools
4. Use ideation techniques to generate a pool of solutions for a problem
5. Create prototypes using different techniques
6. Test the prototypes and gather feedback for refining the prototype

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DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	No perquisites	-	-
I	**Introduction to Design Thinking**	**Introduction to Design Thinking:** Definition, Comparison of Design Thinking and traditional problem-solving approach, Need for Design Thinking approach, Key tenets of Design Thinking, 5 stages of Design Thinking (Empathize, Define, Ideate, Prototype, Test) **Self-learning Topics:** Design thinking case studies from various domains https://www.design-thinking-association.org/explore-design-thinking-topics/external-links/design-thinking-case-study-index	**05**	**L1, L2**
II	**Empathy**	**Empathy:** Foundation of empathy, Purpose of empathy, Observation for empathy, User observation technique, Creation of empathy map **Self-learning Topics:** Creation of empathy maps https://www.interactiondesign.org/literature/topics/empathy-mapping	**05**	**L2, L3**

III	**Define**	**Define:** Significance of defining a problem, Rules of prioritizing problem solving, Conditions for robust problem framing, Problem statement and POV **Self-learning Topics:** Creating a Persona – A step-by-step guide with tips and examples https://uxpressia.com/blog/how-to-create-persona-guide-examples	**05**	**L2, L3**
IV	**Ideate**	**Ideate:** What is ideation? Need for ideation, Ideation techniques, Guidelines for ideation: Multi-disciplinary approach, Imitating with grace, Breaking patterns, Challenging assumptions, Looking across value chain, Looking beyond recommendation, Techniques for ideation: Brainstorming, Mind mapping **Self-learning Topics:** How To Run an Effective Ideation Workshop: A Step-By-Step Guide https://uxplanet.org/how-to-run-an-effective-ideation-workshop-a-step-by-step-guide-d520e41b1b96	**05**	**L3**
V	**Prototype**	**Prototype:** Low and high-fidelity prototypes, Paper prototype, Story board prototype, Scenario prototype	**03**	**L6**
VI	**Test**	**Test:** 5 guidelines of conducting test, The end goals of test: Desirability, Feasibility and Viability, Usability testing	**03**	**L4, L5**

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Textbooks:

1. Design Your Thinking: The Mindsets, Toolsets, and Skill Sets for Creative Problem-solving, Pavan Soni, Penguin Random House India Private Limited
2. Design Thinking: Methodology Book, Emrah Yayichi, 2016
3. Handbook of Design Thinking: Christian Mueller-Roterberg, 2018

Reference books:

1. Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School, Idris Mootee, Wiley, 2013
2. Change by Design, Tim Brown, Harper Business, 2009

Online Resources:

Sr. No.	Website Name
1.	Design Thinking and Innovation by Ravi Poovaiah https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
2.	Introduction to Design Thinking by Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr. Deepali Raheja, Dr. Mansi Kapoor https://onlinecourses.swayam2.ac.in/imb24_mg37/preview
3.	Usability Testing https://www.interaction-design.org/literature/topics/usability-testing

List of Experiments:

The experiments are to be performed in groups. A practical batch may be divided into groups of 4-5 students.

Sr No	List of Experiments	Hrs
01	Customer Journey Mapping: Visualize the steps users take to interact with a product or service. Map out the customer journey from discovering a product to making a purchase and using the product. Identify pain points and opportunities for improvement.	2
02	Stakeholder mapping: Identify all relevant stakeholders in a project. Create a stakeholder map, categorizing stakeholders based on their influence and interest. Include management of relationships with key stakeholders.	2
03	"How Might We" Problem Framing: Transform user insights into actionable problem statements. After empathizing with users, turn challenges into "How Might We" statements that define the problem without prescribing a solution.	2
04	Brainstorming Session: Generate a pool of ideas in a creative, non-judgmental environment. Using ideation techniques like mind mapping and brainwriting, students brainstorm as many solutions as possible to their "How Might We" problem statements.	2
05	Affinity Diagramming: Organize group ideas to find patterns and insights. After brainstorming, students will categorize their ideas into themes by placing sticky notes on a wall and moving them into groups based on similarities.	2
06	Rapid Prototyping: Create quick, low-fidelity versions of solutions. Use materials like paper, cardboard, and markers to build a prototype of their solution within 30 minutes. The focus is on speed and functionality, not aesthetics.	2
07	Wireframing: Create a visual guide for digital interfaces for mobile app / web app for the problems identified in earlier lab sessions. Students will sketch wireframes of the user interface for their product or service. Use tools like Balsamiq or paper and pen for low-fidelity wireframes.	2
08	Role-Playing: Walk through a prototype from the user's perspective. Students act as both users and designers, role-playing scenarios where they interact with their prototype (Developed in earlier lab sessions). Gather feedback from participants on how to improve the experience.	2
09	Usability Testing: Evaluation of the effectiveness and user-friendliness of a prototype (developed in earlier lab sessions). Students will have peers or target users test their prototypes, observe how they interact with it, and collect feedback on any issues or improvements needed.	2
10	Feedback Loop and Iteration: Refine solutions based on user feedback. After usability testing, students will refine their prototypes. Document changes made based on feedback and discuss how continuous iteration improves the design.	2

Sr No	List of Assignments (Any two)	Hrs
01	Create an empathy map for a target user group. Break them into four sections: *Says, Thinks, Feels, and Does*. Interview users or research their experiences to fill in the map.	3
02	Based on research, students will create user personas including demographic details, motivations, pain points, and goals. Each group will present their persona to the class.	3
03	Consider 3 examples of real-life products which have good design and bad design. Write down reasons why do you think they are good or bad designs. May take user survey to support your work.	3
04	Study any open-source design thinking tool and write a brief report about it.	3

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Assessment:

Term Work: Term Work shall consist of 08 to 10 lab activities based on the above list. Also, Term work journal must include any 2 to 4 assignments from the above list.
Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 10 Marks (Assignments) + 5 Marks (Attendance)+ 10 Marks (Report).

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Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2173611	Full Stack Java Programming	-	2*+2	-	-	2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
2173611	Full Stack Java Programming	--	--	--	--	50	25	75

Lab Objectives: This subject seeks to give students an understanding of full stack development in Java. The main aim of this course is to:

1. Familiarize with Basic OOP concepts in Java,
2. Understand the concepts of inheritance and exceptions in java,
3. Design and implement programs involving Client and Server Side Programming,
4. Describe and utilize the functioning of DOM and Java script,
5. Study different design patterns in web programming and understand the working of react framework,
6. To describe the Spring Framework and implement the related case studies.

Lab Outcomes: At the end of the course, the students should be able to:

1. Understand and apply the fundamentals of Java Programming and Object-Oriented Programming,
2. Analyze and Illustrate Inheritance and Exception Handling Mechanisms,
3. Elaborate and design applications using Client and Server Side Programming,
4. Understand the concepts in JavaScript for interactive Web Development,
5. Implement the real-world application development in web programming using React,
6. Design and Develop Enterprise-Level Applications Using the Spring Framework.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic Programming constructs in C & Python.		
I	**Introduction to OOP in Java**	**OOP concepts:** Objects, class, Encapsulation, Abstraction, Inheritance, Polymorphism, message passing. Branching and looping. Class, object, data members, member functions Constructors, types, static members and functions Method overloading Input and output functions in Java, Buffered reader class, scanner class, Packages in java, types, user defined packages. **Self-learning Topics:** Array and Vectors in Java	4	LO 1
II	**Inheritance & Exception Handling**	**Inheritance:** Types of inheritance, Method overriding, super, abstract class and abstract method, final, Multiple inheritances using interface, extends keyword. **Exception Handling:** try, catch, finally, throw and throws, Multiple try and catch blocks, user defined exception. **Self-learning Topics:** Multithreading in Java	3	LO 2
III	**Client and Server Side Programming**	**Java Database Connectivity (JDBC):** JDBC architecture and drivers Connecting to databases	5	LO 3

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		(MySQL, Oracle, etc.) Executing SQL queries using Java Statements. **Client Side Scripting: HTML:** Elements, Attributes, Head, Body, Hyperlink, Formatting, Images, Tables, List, Frames, Forms. **CSS3:**Syntax, Inclusion, Color, Background, Fonts, Tables, lists,CSS3 selectors. **Server side programming in Java:** Introduction of Servlet, Servlet lifecycle, Servlet Request, Servlet Response, Servlet Context, HTTP Sessions, Handling forms and user inputs, Session management. Introduction to Java Server Pages, JSP architecture and page directives, Components of a JSP, Scripting elements and Standard actions, Method Definitions, JSTL. **Self-learning Topics:** Database Connectivity in Servlets and Implement JSP with JDBC to fetch data from a database		
IV	**Fundamentals of Java Script**	**Java Script:** Introduction to JavaScript: Conditionals Statements, Loops, Functions, Arrays, Objects, Control Flow, Math Function, Browser Object Model, Document Object Model. **DOM Manipulation:** Introduction to the DOM, Defining the DOM, Defining DOM, Dom Tree, Language-Specific DOMs, Accessing relative nodes, Checking the node type, Dealing with attributes, Creating and manipulating nodes, DOM HTML Features, Attributes as properties, Table methods, DOM Traversal, NodeIterator, TreeWalker, Selector methods, Detecting DOM Conformance, DOM style methods, Custom tooltips, Collapsible sections, Accessing style sheets Events, Fetch & Callbacks: Event Flow, Event Handlers/Listeners, The Event Object, Types of Events, Cross-Browser Events, HTTP Responses, Working with JSON data. **Self-learning Topics:** AJAX	5	LO 4
V	**Web Programming using React**	**Design Pattern:** Understanding MVC architecture Implementing MVC with servlets and JSP Developing a complete web application Solving company's use cases. **React Framework:** Introduction to React JS, Components and Elements of React, Rendering Components, React State and Props, Events, Hooks, Routing Conditional Rendering, Lists and Keys, Forms, create a single page application using React. **Self-learning Topics:** Flux and Redux	5	LO 5
VI	**Applications of Spring Framework**	**Spring Framework:** Introduction to Microservices, Basics Dependency injection and inversion of control (IoC), Spring annotations, Database integration and Aspect-oriented programming (AOP) with spring, creating spring boot applications, Building RESTful APIs with spring boot. **Self-learning Topics:** Real-time Applications on Spring Framework	4	LO 6

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Text Books:

1. Herbert Schildt, "Java The Complete Reference" Ninth Edition, Oracle Press
2. Christopher Schmitt and Kyle Simpson, "HTML5 Cookbook",O'Really Press
3.Nicholas C. Zakas,"Professional JavaScript™ for Web Developers", Wiley Publishing
4. Amuthan G., "Spring MVC, Beginners Guide" Pakt Publication
5. Chris Minnick,"BEGINNING ReactJS Foundations Building User Interfaces with ReactJS", Wrox publication
6.Iuliana Cosmina, Rob Harrop, "Pro Spring 5 An In-Depth Guide to the Spring Framework and Its Tools",Fifth Edition,APress

Reference Books:

1. Laura Lemay, Charles L. Perkins","Teach Yourself JAVA in 21 Days",Sams.net Publishing
2. Eureka, Ribbon, Zuul and Cucumber Moises Macero,"Learn Microservices with Spring Boot A Practical Approach to RESTful Services using RabbitMQ", APress
3.Alex Banks & Eve Porcello," React FUNCTIONAL WEB DEVELOPMENT WITH REACT AND REDUX", O'Really Press

Online Resources:

Sr. No.	Website Name
1.	https://www.javatpoint.com/html5-tutorial
2.	https://www.w3schools.com/js/
3.	https://www.tutorialspoint.com/spring_boot/index.htm
4.	https://www.w3schools.com/REACT/DEFAULT.ASP

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Suggested list of Experiments		
Sr No	**Title of Experiments**	**Hrs**
01	Programs on classes and objects	2
02	Programs on method and constructor overloading.	2
03	Programs on various types of inheritance and Exception handling	2
04	Program on Implementing Generic and HTTP servlet.	2
05	Design a login webpage in JSP that makes validation through Database using JDBC and call the servlet for various operations	2
06	Program on Implicit and Explicit objects in JSP	2
07	Program to create a website using HTML CSS and JavaScript	2
08	Program using Java Script to validate the email address entered by the user (check the presence of "@" & "." character. If this character is missing, the script should display an alert box reporting the error and ask the user to re-enter it again).	2
09	Program based on Document Object Model to change the background color of the web page automatically after every 5 seconds.	2
10	Program for making use of React Hooks that displays four buttons namely, "Red", "Blue", "Green", "Yellow". On clicking any of these buttons, the code displays the message that you have selected that particular color.	2
11	Creating a Single Page website using the concepts in React like Hooks, Router, Props and States.	2
12	Program to create a Monolithic Application using SpringBoot	2
13	Program for Building RESTful APIs with spring boot	2

Sr No	Suggested List of Assignments / Tutorials	Hrs
1.	Theory Assignment based on Introduction to OOP in Java, Inheritance, Exception Handling and Client/Server Side Programming (Chapter 1 to 3)	4
2.	Theory Assignment based on Fundamentals of Java Script, Web Programming using React and Applications of Spring Framework (Chapter 4 to 6)	4

Assessment:

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments. Mini Project based on the content of the syllabus (Group of 2-3 students), The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

Term Work Marks: Total 50-Marks (Experiments: 15-marks, Attendance: 05-marks, Assignments: 05-marks, Mini Project: 20-marks, MCQ as a part of lab assignments: 5-marks)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

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Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	----	Ab (Absent)	0

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Sd/-

Dr. Subhash K. Shinde
BoS Chairman, Computer Engineering
Faculty of Science & Technology

Sd/-

Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-

Prof. Shivram S. Garje
Dean
Faculty of Science & Technology