University of Mumbai

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विद्याविषयक प्राधिकरणे
सभा आणि सेवा विभाग(ए.ए.एम.एस)
रूम नं. १२८ एम.जी.रोड, फोर्ट,
मुंबई – ४०० ०३२
टेलिफोन नं. – ०२२ – ६८३२००३३

(नॅक पुनर्मूल्यांकनाद्वारे ३.६५ (सी.जी.पी.ए.) सह अ++ श्रेणी
विद्यापीठ अनुदान आयोगाद्वारे श्रेणी १ विद्यापीठ दर्जा)

क्र.वि.प्रा.स.से./आयसीडी/२०२५-२६/३७ दिनांक : २७ मे, २०२५

परिपत्रक:-

सर्व प्राचार्य/संचालक, संलग्नित महाविद्यालये/संस्था, विद्यापीठ शैक्षणिक विभागांचे संचालक/ विभाग प्रमुख यांना कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण २०२० च्या अमंलबजावणीच्या अनुषंगाने **शैक्षणिक वर्ष २०२५-२६** पासून **पदवी व पदव्युत्तर अभ्यासक्रम** विद्यापरिषदेच्या दिनांक २८ मार्च २०२५ व २० मे, २०२५ च्या बैठकीमध्ये मंजूर झालेले सर्व अभ्यासक्रम मुंबई विद्यापीठाच्या www.mu.ac.in या संकेत स्थळावर NEP २०२० या टॅब वर उपलब्ध करण्यात आलेले आहेत.

मुंबई – ४०० ०३२
२७ मे, २०२५

(डॉ. प्रसाद कारंडे)
कुलसचिव

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Copy forwarded for information and necessary action to :-	
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8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
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6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

AC – 20/5/2025
Item No. – 6.49 (N)

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4, 5 & 6		
Name of the Programme – B.E. (Data Engineering)		
Faculty of Engineering		
Board of Studies in Data Engineering		
U.G. Second Year Programme	**Exit Degree**	**U.G. Diploma in Data Engineering.**
Semester		**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. (Data Engineering)**
2	**Exit Degree**	**U.G. Diploma in Data Engineering.**
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. TEU-670C** **R. TEU-670D**	**Attached herewith**
6	**Semesters**	**Sem. IV**
7	**Program Academic Level**	**5.00**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2025-26**

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 Data Engineering 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 Data Engineering 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 Data Engineering 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.

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**

Under Graduate Diploma in Engineering- Data Engineering,

Credit Structure (Sem. III & IV)

	R. TEU-670C								
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. TEU-670D									
	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]

S.E.
Data Engineering Scheme

Program Structure for Second Year of Computer 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
2204111	Computational Theory	3	--	--	3	--	--	3
2204112	Database Management System	3	–	--	3	--	--	3
2204113	Operating System	3	--	--	3	--	--	3
MDC401	Multidisciplinary minor	3	--	--	3	--	--	3
2204311	Open Elective	2#	--	--	2	--	--	2
2204114	Database Management System Lab	--	2	--	--	--	1	1
2204115	Operating System Lab	--	2	--	--	--	1	1
MDL401	Multidisciplinary minor	--	2	--	--	--	1	1
2204411	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.

Program Structure for Second Year of Data Engineering

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)					
2204111	Computational Theory	20	20	40	60	2	--	--	100
2204112	Database Management System	20	20	40	60	2	--	--	100
2204113	Operating System	20	20	40	60	2	--	--	100
MDC401	Multidisciplinary minor	20	20	40	60	2	--	--	100
2204311	Open Elective	20	20	40	60	2	--	--	100
2204114	Database Management System Lab	--	--	--	--	--	25	25	50
2204115	Operating System Lab	--	--	--	--	--	25	25	50
MDL401	Multidisciplinary minor Lab	--	--	--	--	--	25	--	25
2204411	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**

Vertical – 1
Major

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2204111	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					
2204111	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.

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	**6**	**CO2**

		output: Moore and Mealy machines, Applications and limitations of FA.		
		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.

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

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2204112	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.					
2204112	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

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	**08**	**CO1**

		constraints: Cardinality and Participation, Extended Entity-Relationship (EER) Model: 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**

Text Books:

1. Elmasri and Navathe, Fundamentals of Database Systems, 7thEdition, Pearson Education
2. Korth, Slberchatz, Sudarshan, Database System Concepts, 7thEdition, 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.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical /Oral	Tutorial	Total
2204113	**Operating System**	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme						
		Theory Marks						
		Internal assessment			End Sem. Exam	Term Work	Pract. /Oral	Total
		Test1	Test 2	Total				
2204113	**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

		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

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.

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
2204114	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				
2204114	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
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**.**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2204115	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				
2204115	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
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

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.

Vertical – 4

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2204411	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				
2204411	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.

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.

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

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**

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

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.

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**

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

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

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**

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.	3

	May take user survey to support your work.	
04	Study any open-source design thinking tool and write a brief report about it.	3

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).

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

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