

Institute/Department	UNIVERSITY INSTITUTE OF ENGINEERING (UIE)	Program	Bachelor of Engineering (Artificial Intelligence and Data Science) (AI201)
Master Subject Coordinator Name:	Kamaljeet Kaur	Master Subject Coordinator E-Code:	E19147
Course Name	System Design	Course Code	23CST-390

Lecture	Tutorial	Practical	Self Study	Skilling	TC	TGT	TGP	Studio	Credit	Subject Type
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Course Type	Course Category	Mode of Assessment	Mode of Delivery
Major Core	Graded (GR)	Theory Examination (ET)	Theory (TH)

Mission of the Department	<p>M1: To provide relevant, rigorous and contemporary curriculum and aligned assessment system to ensure effective learning outcomes for engineering technologies.</p> <p>M2: To provide platform for industry engagement aimed at providing hands-on training on advanced technological and business skills to our students.</p> <p>M3: To provide opportunities for collaborative, interdisciplinary and cutting-edge research aimed at developing solutions to real life problems.</p> <p>M4: To imbibe quest for innovation, continuous learning and zeal to pursue excellence through hard work and problem-solving approach.</p> <p>M5: To foster skills of leadership, management, communication, team spirit and strong professional ethics in all academic and societal endeavours of our students.</p>
Vision of the Department	To be recognized as a centre of excellence for Computer Science & Engineering education and research, through effective teaching practices, hands-on training on cutting edge computing technologies and excellence in innovation, for creating globally aware competent professionals with strong work ethics whom would be proficient in implementing modern technology solutions and shall have entrepreneurial zeal to solve problems of organizations and society at large.

#### Program Educational Objectives(PEOs)

PEO1	To be able to explore areas of research, technology application & innovation and make a positive impact in different types of institutional settings such as corporate entities, government bodies, NGOs, inter-government organizations, & start-ups.
PEO2	To be able to design, and implement technology and computing solutions to organizational problems, effectively deploy knowledge of engineering principles, demonstrate critical thinking skills & make the intellectual connections between quantitative and qualitative tools, theories, and context to solve the organizational problems
PEO3	To be able to work with, lead & engage big and small teams comprising diverse people in terms of gender, nationality, region, language, culture & beliefs. To understand stated and unstated differences of views, beliefs & customs in diverse & interdisciplinary team settings
PEO4	To be able to continuously learn and update one's knowledge, engage in lifelong learning habits and acquire latest knowledge to perform in current work settings
PEO5	To continuously strive for justice, ethics, equality, honesty, and integrity both in personal and professional pursuits. Able to understand and conduct in a way that is responsible and respectful.

#### Program Specific Outcomes(PSOs)

PSO1	PSO1: Graduates will be able to analyze, design, and develop intelligent systems and applications by applying core concepts of Artificial Intelligence and Machine Learning across diverse domains.
PSO2	PSO2: Graduates will demonstrate proficiency in utilizing advanced AI/ML tools, frameworks, and technologies to innovate, implement, and manage projects in the rapidly evolving field of Artificial Intelligence and its allied application areas.
PSO3	PSO3: Graduates will apply AI, Machine Learning, and Data Analytics techniques to address real-world challenges, delivering effective and ethical solutions for industry, research, and societal needs.

#### Program Outcomes(POs)

PO1	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
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PO2	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, societal, and environmental considerations.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations PO4 Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO7	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context to technological change.
PO13	Demonstrate the capability to apply analytic thought to a body of knowledge, including the analysis and evaluation of policies, and practices. Identify relevant assumptions or implications, logical flaws and loopholes in the presented arguments
PO14	Demonstrate to create, perform, or think in different and diverse ways about the given scenario. Innovate and perform tasks in a better manner, view a problem or a situation from multiple perspectives, think 'out of the box' and generate solutions to complex problems in unfamiliar contexts
PO15	Demonstrate the ability to identify with or understand the perspective, experiences, or points of view of another individual or group, and to identify and understand other people's emotions
PO16	Demonstrate the ability to participate in community-engaged services/ activities for promoting the well-being of society
PO17	Demonstrate the acquisition of knowledge of the values and beliefs of multiple cultures, capability to effectively engage in a multicultural group/society and interact respectfully with diverse groups and gender sensitivity and adopting a gender-neutral approach, as also empathy for the less advantaged and the differently-abled including those with learning disabilities.

### Text Books

Sr No	Title of the Book	Author Name	Volume/Edition	Publish Hours	Years
1	Designing Data-Intensive Applications	Martin Kleppmann	O'Reilly Media, 1st Edition	The Big Ideas Behind Reliable, Scalable, and Main	2017
2	System Design Interview	Alex Xu	1st Edition	An Insider's Guide, Createspace Independent Publis	2017
3	Microservices Patterns With Examples in Java	Chris Richardson	1st Edition	Manning Publications	2018
4	Cloud Native Patterns: Designing Change-Tolerant Software	Cornelia Davis	1st Edition	Manning Publications	2020
5	Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Sys	Martin Kleppmann	1st Edition	O'Reilly Media	2017
6	Designing Distributed Systems: Patterns and Paradigms for Scalable, Reliable Services	Brendan Burns	1st Edition	O'Reilly Media	2018



Reference Books					
Sr No	Title of the Book	Author Name	Volume/Edition	Publish Hours	Years
1	Building Microservices: Designing Fine-Grained Systems	Sam Newman	1st Edition,	O'Reilly Media	2015
2	Patterns of Enterprise Application Architecture	Martin Fowler	1st Edition	Addison-Wesley	2002
3	Distributed Systems: Concepts and Design,	James W. Wilson	5th Edition	Pearson	2018
4	Building Microservices: Designing Fine-Grained Systems	Sam Newman	1st Edition	O'Reilly Media	2015
5	The Definitive Guide: Real-Time Data and Stream Processing at Scale	O'Reilly Media	2nd Edition	Gwen Shapira, Todd Palino, Rajini Sivaram, Neha Na	2021
6	Microservices Security in Action	Prabath Siriwardena, Nuwan Dias	1st Edition	Manning Publications	2020
7	Site Reliability Engineering: How Google Runs Production Systems	Betsy Beyer, Chris Jones, Jennifer Petoff, Niall R	1st Edition	O'Reilly Media	2016
8	Fundamentals of Software Architecture: An Engineering Approach	Mark Richards, Neal Ford	1st Edition	O'Reilly Media	2020

Course OutCome	
SrNo	OutCome
CO1	Understand the fundamental system design principles, and fault tolerance, while analyzing how these core principles influence architectural decisions in real-world distributed environments.
CO2	Apply various distributed architectural patterns, key database models, and critical communication protocols to evaluate their specific applications and trade-offs in modern system designs.
CO3	Apply advanced scaling techniques, such as caching, load balancing, database sharding, and replication, to design system components that effectively handle massive user traffic and data volumes.
CO4	Analyze the trade-offs between different system architectures, data storage, and consistency models to select and justify optimized configurations for performance, cost, and reliability goals.
CO5	Create and document comprehensive, end-to-end system designs that are inherently scalable, and fault-tolerant, leveraging modern paradigms such as cloud computing and microservices architecture.

Lecture Plan Preview-Theory							
Unit No	LectureNo	ChapterName	Topic	Text/ Reference Books	Pedagogical Tool**	Mapped with CO Number(s)	BT Level
1	1	Introduction to System Design	Introduction to System Design – Core Concepts	,T-Designing Data-Intensive Appli,R-Building Microservices: Design	PPT,Video Lecture	CO1	BT2
1	2	Introduction to System Design	Functional vs. Non-Functional Requirements	,T-Designing Data-Intensive Appli,R-Building Microservices: Design	PPT,Video Lecture	CO1	BT2
1	3	Introduction to System Design	Scaling Challenges: Horizontal vs. Vertical Scaling	,T-System Design Interview ,R-Distributed Systems: Concepts	Case Study,PPT,V ideo Lecture	CO1	BT2
1	4	Introduction to System Design	Load Balancing – Principles and Deployment Strategies	,T-System Design Interview ,R-Patterns of Enterprise Applica	PPT,Simulati on,Video Lecture	CO3	BT3
1	5	Introduction to System Design	Load Balancing Algorithms (RR, Weighted RR, Least Connection)	,T-Designing Data-Intensive Appli,R-Building Microservices: Design	PPT,Video Lecture	CO3	BT3



1	6	Introduction to System Design	Caching Strategies – Cache Placement and Policy	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Building Microservices: Design	Flipped Classes,PPT ,Video Lecture	CO3	BT3
1	7	Introduction to System Design	Client-Side vs. Server-Side Caching (Self-Study Review) & CDN Basics	,T-System Design Interview ,R-Patterns of Enterprise Appli	PPT,Simulation,Video Lecture	CO3	BT3
1	8	Introduction to System Design	Cache Invalidation and Advanced Caching Patterns	,T-System Design Interview ,R-Patterns of Enterprise Appli	Case Study,PPT,Video Lecture	CO3	BT3
1	9	Introduction to System Design	Replication – Master-Slave and Multi-Master Architectures	,T-Cloud Native Patterns: Design,T-Designing Data-Intensive Appli,R-Building Microservices: Design	Activity,Case Study,PPT,Video Lecture	CO1	BT2
1	10	Introduction to System Design	Replication Techniques (Synchronous/Asynchronous) & Consistency	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Building Microservices: Design,R-Patterns of Enterprise Appli	PPT,Video Lecture	CO3	BT3
1	11	Databases in System Design	Sharding – Principles and Partitioning Schemes (Key, Hash, Range)	,T-System Design Interview ,R-Distributed Systems: Concepts	Case Study,PPT,Video Lecture	CO3	BT3
1	12	Databases in System Design	Sharding Strategies (Self-Study Review) & Resharding Challenges	,T-Microservices Patterns With Ex,R-Distributed Systems: Concepts	Flipped Classes,PPT ,Video Lecture	CO4	BT4
1	13	Databases in System Design	SQL vs. NoSQL Rationale, CAP Theorem and BASE Principles, Distributed Databases and Eventual Consistency	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Distributed Systems: Concepts	PPT,Video Lecture	CO2	BT3
1	14	Databases in System Design	Distributed Caching: Deep Dive into Redis and Memcached, High Availability and Fault Tolerance Mechanisms	,T-Microservices Patterns With Ex,R-Distributed Systems: Concepts	Case Study,PPT,Reports,Video Lecture	CO1	BT2
1	15	Databases in System Design	Microservices vs. Monolithic Architecture Comparison	,T-Cloud Native Patterns: Design,R-Distributed Systems: Concepts	PPT,Simulation,Video Lecture	CO5	BT6
2	16	Real-World System Architectures	Designing for Millions of Users – Traffic Modeling and Estimation	,T-Designing Data-Intensive Appli,R-Building Microservices: Design	Case Study,PPT,Professor of Practice/Adjunct Faculty/Visiting Professor,Reports	CO5	BT6
2	17	Real-World System Architectures	Rate Limiting – Techniques and Implementation	,T-Designing Data-Intensive Appli,R-Patterns of Enterprise Appli	Activity,PPT, Reports	CO3	BT3
2	18	Real-World System Architectures	Advanced Rate Limiting Techniques & Distributed Limits	,T-System Design Interview ,R-Distributed Systems: Concepts	Case Study,PPT,Simulation	CO4	BT4
2	19	Real-World System Architectures	API Gateway Architecture	,T-Microservices Patterns With Ex,R-Patterns of Enterprise Appli	Activity,PPT, Video Lecture	CO2	BT3
2	20	Real-World System Architectures	CDNs Overview	,T-Designing Data-Intensive Appli,R-Distributed Systems: Concepts	Case Study,PPT,Simulation	CO2	BT3
2	21	Real-World System Architectures	Messaging Queues (Kafka)	,T-Designing Data-Intensive Appli,R-Microservices Security in Acti	Case Study,PPT,Reports,Video Lecture	CO2	BT3
2	22	Real-World System Architectures	Messaging Queues (RabbitMQ)	,T-System Design Interview ,R-Site Reliability Engineering:	Case Study,PPT,Video Lecture	CO2	BT3



2	23	Real-World System Architectures	Event-Driven Systems	,T-Designing Distributed Systems:,R-Fundamentals of Software Archi	PPT,Video Lecture	CO2	BT3
2	24	Real-World System Architectures	OAuth Fundamentals	,T-System Design Interview ,R-The Definitive Guide: Real-Tim	Case Study,PPT,V ideo Lecture	CO2	BT3
2	25	Security in System Design	JWT Authentication	,T-Cloud Native Patterns: Designi,R-Site Reliability Engineering:	PPT,Simulati on,Video Lecture	CO2	BT3
2	26	Security in System Design	API Security	,T-System Design Interview ,R-Microservices Security in Acti	PPT,Simulati on	CO2	BT3
2	27	Case study	Case Study: Designing a VOD/Streaming Service (Netflix)	,T-Cloud Native Patterns: Designi,R-Site Reliability Engineering: ,R-The Definitive Guide: Real-Tim	Case Study,PPT,R eports,Video Lecture	CO4	BT4
2	28	Case study	Case Study: Designing a Real-Time Geo-Spatial System (Uber)	,T-System Design Interview ,R-Building Microservices: Design,R-Fundamentals of Software Archi	Activity,Case Study,PPT	CO4	BT4
2	29	Case study	Case Study: Designing a Social Network Feed (Facebook)	,T-Designing Data-Intensive Appli,T-Microservices Patterns With Ex,T-System Design Interview ,R-Distributed Systems: Concepts ,R-The Definitive Guide: Real-Tim	Activity,Case Study,PPT,V ideo Lecture	CO5	BT6
2	30	Case study	Case Study: Designing a Large-Scale Chat Application (WhatsApp)	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Building Microservices: Design,R-Site Reliability Engineering: ,R-The Definitive Guide: Real-Tim	Case Study,PPT,R eports,Video Lecture	CO4	BT4
3	31	Project Development	Designing Search Engines: Components, Indexing, and Queries	,T-Microservices Patterns With Ex,T-System Design Interview ,R-Microservices Security in Acti,R-Site Reliability Engineering:	PPT,Video Lecture	CO3	BT3
3	32	Project Development	Search Engine Ranking Algorithms	,T-Designing Data-Intensive Appli,T-Designing Distributed Systems: ,R-Distributed Systems: Concepts ,R-The Definitive Guide: Real-Tim	Activity,PPT, Video Lecture	CO3	BT3
3	33	Project Development	Architecture of Designing Search Engines	,T-Cloud Native Patterns: Designi,T-Designing Distributed Systems:,R-Microservices Security in Acti,R-Patterns of Enterprise Applica,R-The Definitive Guide: Real-Tim	PPT,Reports ,Video Lecture	CO5	BT6
3	34	Project Development	Designing Recommendation Systems (CF vs. Content-Based)	,T-Cloud Native Patterns: Designi,T-Designing Data-Intensive Appli,T-Microservices Patterns With Ex,R-Microservices Security in Acti,R-Site Reliability Engineering:	Activity,PPT, Reports,Vide o Lecture	CO3	BT3
3	35	Project Development	System Design Interview Strategies	,T-Cloud Native Patterns: Designi,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Building Microservices: Design,R-Microservices Security in Acti,R-Patterns of Enterprise Appica	Activity,PPT, Video Lecture	CO5	BT6
3	36	Cost Estimation	Cost Estimation in Distributed Systems & Cloud Cost Models	,T-Cloud Native Patterns: Designi,T-Designing Distributed Systems:,T-System Design Interview ,R-Microservices Security in Acti,R-Patterns of Enterprise Applica	PPT,Simulati on,Video Lecture	CO4	BT4
3	37	Cost Estimation	Trade-Offs in System Architecture	,T-Cloud Native Patterns: Designi,T-Designing Data-Intensive Appli,R-Building Microservices: Design,R-Distributed Systems: Concepts	Flipped Classes,PPT ,Reports	CO4	BT4



3	38	Cost Estimation	Techniques of Optimization	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Building Microservices: Design,R-Microservices Security in Acti,R-Patterns of Enterprise Applica	PPT,Video Lecture	CO4	BT4
3	39	Cost Estimation	Requirements for Final Project Planning	,T-Designing Data-Intensive Appli,R-Building Microservices: Design	Activity,PPT	CO5	BT6
3	40	Cost Estimation	Final Project Planning: Requirements, Diagrams	,T-Designing Data-Intensive Appli,T-System Design Interview ,R-Distributed Systems: Concepts ,R-The Definitive Guide: Real-Tim	PPT,Simulation	CO5	BT6
3	41	Cost Estimation	Component Selection of Final Project Planning	,T-Cloud Native Patterns: Designi,R-Patterns of Enterprise Applica	PPT	CO5	BT6
3	42	Project Development Workshop	Project Development Workshop I: Component Deep Dive & Peer Review	,T-Designing Data-Intensive Appli,R-Patterns of Enterprise Applica	Case Study,Instructor Lead WorkShop	CO5	BT6
3	43	Project Development Workshop	Project Development Workshop II: Integration and Final Feedback	,T-System Design Interview ,R-Site Reliability Engineering:	Case Study,Instructor Lead WorkShop	CO5	BT6
3	44	Surprise Test	Surprise test 1	,T-Designing Data-Intensive Appli,R-Fundamentals of Software Archi	Activity,Case Study,Reports	CO1	BT2
3	45	Surprise Test	Surprise test 2	,T-Microservices Patterns With Ex,T-System Design Interview ,R-Building Microservices: Design,R-The Definitive Guide: Real-Tim	Activity	CO5	BT6

Assessment Model			
Sr No	Exam Name	Max Marks	Weighted Marks
1	External Theory	60	60
2	Assignment/PBL	10	10
3	Attendance Marks	2	2
4	Mid-Semester Test-1	20	10
5	Quiz	4	4
6	Surprise Test	12	4
7	Mid-Semester Test-2	20	10



CO vs PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
CO1	3	2	2	1	2	NA	NA	NA	NA	1	NA	1	2	NA	NA
CO2	3	3	2	2	3	NA	NA	NA	NA	1	NA	1	2	NA	NA
CO3	3	2	3	2	3	NA	NA	NA	NA	1	NA	1	2	1	NA
CO4	2	3	2	3	2	NA	NA	NA	NA	1	NA	1	3	NA	NA
CO5	2	2	3	3	3	1	1	1	2	3	2	2	3	2	NA
Target	2.6	2.4	2.4	2.2	2.6	1	1	1	2	1.4	2	1.2	2.4	1.5	NA

PO16	PO17	PSO1	PSO2	PSO3
NA	NA	1	NA	NA
NA	NA	2	2	NA
NA	NA	2	3	NA
NA	NA	2	2	1
NA	1	3	2	2
NA	1	2	2.25	1.5

