Department of Computer Science and Engineering

B.Tech. Computer Science and Engineering

Course Name	:	**Human Computer Interaction**
Course Code	:	**TCS756**
Semester	:	**VII**
Pre-requisite	:	**Software Engineering (TCS611)**

L	T	P	Credits
3	0	0	3

Course Learning Objectives:

- To introduce students to the fundamental concepts of Human Computer Interaction (HCI), human information processing, user interface design, and the importance of usability in interactive systems.
- To develop an understanding of HCI models, interaction styles, historical paradigms, and user interface concepts for designing effective and user-centered applications.
- To enable students to apply user-centered design processes, universal design principles, HCI standards, and interface design guidelines for developing intuitive and accessible user interfaces.
- To build analytical skills for evaluating user models, stakeholder requirements, socio-organizational issues, and user support mechanisms to improve the usability and effectiveness of interactive systems.
- To develop the ability to design and evaluate Human Computer Interaction systems through task analysis, dialog design, screen design, navigation techniques, and appropriate interaction methods to enhance user experience.

Course Outcomes:

After completion of the course, the students will be able to:

Course Outcome	Statement	Bloom's Level	Skill
CO1	Explain the capabilities of humans and computers from the viewpoint of human information processing and Human Computer Interaction fundamentals.	**L2 – Understand**	Understanding, Analytical Thinking
CO2	Describe Human Computer Interaction (HCI) models, interaction styles, historical paradigms, and user interface concepts.	**L2 – understand**	Understanding, Conceptual Thinking
CO3	Apply interactive design processes, universal design principles, HCI design principles, standards, and guidelines to develop effective user interfaces.	**L3 – Apply**	Design, Programming, Problem Solving
CO4	Analyse user models, user support, socio-organizational issues, and stakeholder requirements for designing effective HCI systems.	**L4 – Analyze**	Critical Thinking, Analytical Thinking, Problem Solving

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CO5	Design and evaluate HCI systems through task analysis, dialog design, screen design, navigation, and interaction techniques.	**L6 – Create**	Design, Creativity, Problem Solving, Evaluation

Details of the Course:

Unit 1: Introduction **Contact Hours/Teaching Hours: 09**

Introduction to Human Computer Interaction (HCI), Importance of User Interface, Definition and Importance of Good User Interface Design, Benefits of Good Design, A Brief History of Screen Design, Graphical User Interface (GUI), Popularity of Graphics, Concept of Direct Manipulation, Graphical Systems and their Characteristics, Web User Interface, Popularity and Characteristics of Web Interfaces, Principles of User Interface Design.

Self-Learning Hours = 6

Students shall explore the evolution of user interfaces, study examples of graphical and web-based interfaces, identify the principles of good user interface design, and evaluate the usability of commonly used software applications and websites.

Team Activity Hours = 3

Group discussion and presentation on comparing graphical user interfaces of different desktop and web applications, identifying good and poor design practices based on established user interface principles, and suggesting improvements to enhance usability.

Unit 2: Design Process

Contact Hours/Teaching Hours: 08

Design Process, Human Interaction with Computers, Importance of Human Characteristics, Human Considerations in Interface Design, Human Interaction Speeds, Understanding Business Functions.

Self-Learning Hours = 6

Students shall study human cognitive and physical characteristics that influence interface design, explore the stages of the user centred design process, analyse real-world user interfaces from usability and accessibility perspectives, and investigate the impact of human interaction speeds on system performance.

Team Activity Hours = 3

Students shall work in groups to analyse the design of existing software or web applications, identify human factors affecting usability, discuss business requirements influencing interface design, and present recommendations for improving the overall user experience.

Unit 3: Screen Designing

Contact Hours/Teaching Hours: 10

Design Goals, Screen Planning and Purpose, Organizing Screen Elements, Ordering of Screen Data and Content, Screen Navigation and Flow, Visually Pleasing Composition, Amount of Information, Focus and Emphasis, Presenting Information Simply and Meaningfully, Information Retrieval on the Web, Statistical Graphics, Technological Considerations in Interface Design.

Self-Learning Hours = 6

Students shall explore the principles of effective screen design, evaluate the layout and navigation of existing desktop and web interfaces, study techniques for presenting information clearly through visual elements and statistical graphics, and examine technological factors influencing interface design.

Team Activity Hours = 3

Students shall work in groups to evaluate the usability of selected software or web interfaces, identify strengths and weaknesses in screen design, navigation, and information presentation, and propose improved interface layouts based on HCI design principles.

Unit 4: Windows

Contact Hours/Teaching Hours: 09

Windows – New and Navigation schemes selection of window, selection of devices based and screen-based controls. Components – text and messages, Icons and increases – Multimedia, colours, uses problems, choosing colours.

Self-Learning Hours = 6

Students shall study different types of windows, navigation schemes, and interface controls, explore the role of text, icons, multimedia, and colour in enhancing usability, and analyse the effectiveness of interface components used in popular desktop and web applications.

Team Activity Hours = 3

Students shall work in groups to evaluate the interface components of existing software applications, compare window navigation techniques and control mechanisms, assess the use of colours and multimedia elements, and recommend improvements based on usability and accessibility principles.

Unit 5: Software Tools

Contact Hours/Teaching Hours: 09

Software tools – Specification methods, interface – Building Tools. Interaction Devices – Keyboard and function keys – pointing devices – speech recognition digitization and generation – image and video displays. Drivers

Self-Learning Hours = 6

Students shall explore various interface specification and interface-building tools, study the working principles and applications of different interaction devices, investigate advancements in speech recognition and multimedia technologies, and analyse the role of device drivers in enabling effective human-computer interaction.

Team Activity Hours = 3

Students shall work in groups to compare different interface development tools and interaction devices, demonstrate the functionality of input and output devices used in HCI systems, and present their findings on emerging interaction technologies and their applications in modern user interfaces.

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Course Articulation Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	2								1		2	2	2	
CO02	2	2	1							2		2	2	2	1
CO03	2	2	3	2	3				1	2		2	3	2	2
CO04	1	3	2	2	2	2	1	1	2	2		2	3	2	2
CO05	2	3	3	3	3	1		1	2	2	1	2	3	2	3
Avg.	2	3	2	1	2	1	1	1	1	2	1	2	3	2	2

Text Books:

1. Wilbert O Galitz. (2016). *The essential guide to user interface design",* 2nd Edition, Wiley Dreama Tech.
2. Ben Shneidermann (2009), *"Designing the user interface",* 3rd Edition, Pearson Education Asia.

Reference Books:

1. Alan Dix, Janet Fincay, Gre Goryd, Abowd, Russell Bealg, (2003), *Human Computer Interaction*, Pearson Education, New Delhi, 3rd Edition.

Online Resources:

1. **ILearn Platform GEHU- Human Computer Interaction (HCI)**
   https://ilearn.gehu.ac.in/s/mycourses
2. **GeeksforGeeks – Human Computer Interaction (HCI)**
   https://www.geeksforgeeks.org/human-computer-interaction-hci/
3. **NPTEL – Human Computer Interaction**
   https://nptel.ac.in/
4. **Interaction Design Foundation (IDF) – Human-Computer Interaction**
   https://www.interaction-design.org/
5. **Nielsen Norman Group (NN/g) – UX and Usability Resources**
   https://www.nngroup.com/
6. **W3C Web Accessibility Initiative (WAI)**
   https://www.w3.org/WAI/

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Department of Computer Science and Engineering

B.Tech. Computer Science and Engineering

Course Name	:	**Business Intelligence**
Course Code	:	**TCS726**
Semester	:	**VII**
Pre-requisite	:	**Bigdata Visualization (TCS571), Bigdata storage and processing (TCS671)**

L	T	P	Credits
3	0	0	3

Course Learning Objectives:

- Develop an understanding of the role of Business Intelligence (BI) in organizational decision-making and business process improvement.
- Introduce different types of digital data and techniques for managing structured, semi-structured, and unstructured data.
- Provide knowledge of OLTP, OLAP, multidimensional data models, and data warehousing concepts for analytical processing.
- Familiarize students with BI architectures, frameworks, data warehouse design, and modern BI tools.
- Enable students to apply performance management, dashboards, KPIs, enterprise reporting, cloud-based BI, and ERP-based BI solutions.

Course Outcomes:

After completion of the course, the students will be able to:

CO	Statement	Bloom's Level	Skill
CO1	Explain Business Intelligence concepts, enterprise applications, business processes, and the role of BI in organizational decision-making.	**L2 – Understand**	Conceptual Understanding, Analytical Thinking
CO2	Analyze structured, semi-structured, and unstructured data and recommend appropriate techniques for data storage, management, and retrieval.	**L4 – Analyze**	Data Analysis, Problem Solving
CO3	Apply OLTP, OLAP, multidimensional modeling, and data warehousing concepts to design analytical solutions for business applications.	**L3 – Apply**	Database Design, Analytical Skills
CO4	Design Business Intelligence architectures and data warehouse models using appropriate BI frameworks, tools, and dimensional modelling techniques.	**L3 – Apply**	System Design, Tool Utilization
CO5	Evaluate business performance using KPIs, dashboards, enterprise reporting, cloud-based BI, and ERP-enabled Business Intelligence solutions.	**L5 – Evaluate**	Decision Making, Critical Thinking

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Details of the Course:

Unit 1: Business View of Information Technology

Contact Hours/Teaching Hours: 09

Business view of Information Technology Application, Business Enterprise Organization, its functions, and core business process, Baldrige Business Excellence Framework: - Leadership, Strategic Planning, Customer Focus, Measurement, Analysis and Knowledge.

Management Workforce Focus, Process Management, Key Purpose of using IT in Business, Enterprise Application (ERP/CRM etc) and Bespoke IT Application.

Self-Learning Hours = 06

Students shall study the organizational structure and core business processes of various enterprises, analyze the implementation of ERP and CRM systems in organizations, and explore the application of the Baldrige Business Excellence Framework through real-world business case studies.

Team Activity Hours = 03

Group activity on analysing the business processes of an organization and identifying opportunities for Information Technology integration using enterprise applications such as ERP and CRM. Students shall present a case study highlighting how IT enables business excellence and improves organizational performance.

Unit 2: Types of Digital Data

Contact Hours/Teaching Hours: 09

Types of Digital Data, getting to know structured data, characteristics of structured data, were does structured data come from? Hassle free Retrieval

Getting to know unstructured data, were does unstructured data comes from? How to manage unstructured data? How to store unstructured data? Solutions to storage challenges of unstructured data, how to extract information from stored unstructured data? UIMA: A possible solution for unstructured data

Getting to know semi structured data, where does semi structured data come from? How to manage semi structured data, modeling semi structured data (OEM), How to extract information from semi structured data, XML: A solution for semi structured data Management.

Self-Learning Hours = 06

Students shall explore various sources of structured, unstructured, and semi-structured data, study XML document creation and validation, and investigate modern techniques and tools for managing and extracting information from different types of digital data.

Team Activity Hours = 03

Group activity on identifying structured, unstructured, and semi-structured datasets from real-world applications. Students shall compare their characteristics, discuss suitable storage and management techniques, and demonstrate the use of XML or UIMA-based solutions for effective data organization and information extraction.

Unit 3: Introduction to OLTP and OLAP

Contact Hours/Teaching Hours: 10

OLTP: - Queries that an OLTP system can process, Advantage of an OLTP system, Challenges of an OLTP system, The queries that OLTP cannot answer.

OLAP: -one dimension data, two-dimension data, three-dimension data, should we go beyond the third dimension, queries that an OLAP system can process, Advantage of an OLAP system Different OLAP Architecture: -MOLAP, ROLAP, HOLAP Data Models for OLTP and OLAP, Role of OLAP tools in the BI Architecture, OLAP operations on multidimensional data.

Self-Learning Hours = 06

Students shall study the architecture and applications of OLTP and OLAP systems, compare different OLAP architectures (MOLAP, ROLAP, and HOLAP), and perform multidimensional data analysis using sample business datasets and OLAP tools.

Team Activity Hours = 03

Group activity on designing a multidimensional data cube for a business application such as retail sales, banking, or healthcare. Students shall perform various OLAP operations (Roll-up, Drill-down, Slice, Dice, and Pivot) on the data cube and present analytical insights for business decision-making.

Unit 4: Business Intelligence Framework and Data Warehouse

Contact Hours/Teaching Hours: 10

BI component framework: Business layer, Administration and operational layer, Implementation layer.

Who is BI for? - BI for Management, Operational BI, BI for process Improvement, BI to improve customer experience.

Business Intelligence Application: -Technology Solutions, Business solutions.

BI roles and Responsibility: -BI program team roles, BI project team roles, best practice in BI/DW, Popular BI tools. Need for Data Warehouse, what is a Data Mart, Goals of a Data Warehouse.

Multidimensional data modeling: - Data Modeling Basics, Types of Data model, Data Modeling Techniques, Fact table, Dimension table, Dimensional modeling life cycle.

Self-Learning Hours = 06

Students shall study the architecture of Business Intelligence frameworks, explore the features of popular BI tools, design dimensional data models for business applications, and understand the implementation of data warehouses and data marts in enterprise environments.

Team Activity Hours = 03

Group activity on designing a Business Intelligence solution for an organization by identifying the appropriate BI framework, selecting suitable BI tools, and developing a multidimensional data model consisting of fact and dimension tables for a real-world business scenario. Students shall present their proposed BI architecture and justify its role in supporting organizational decision-making.

Unit 5: Performance Management, Enterprise Reporting and Cloud Business Intelligence

Contact Hours/Teaching Hours: 08

Measure, Metrics, KPIs, and Performance Management Understanding Measure and performance, Measurement system terminology, Fact based Decision Making and KPIS, KPI usage in companies.

Basics of Enterprise Reporting: - Report standardization and presentation practices, Enterprise reporting characteristics in OLAP world, Balance score cards, Dashboards, how do you create Dashboards, Scorecards Vs Dashboards. BI and Cloud Computing, Business Intelligence for ERP systems

Self-Learning Hours = 06

Students shall study KPI frameworks adopted by leading organizations, analyze enterprise reports and dashboards developed using modern BI tools, and explore cloud-based Business Intelligence platforms and their integration with ERP systems.

Team Activity Hours = 03

Group activity on designing a Business Intelligence dashboard for a selected business organization by identifying suitable KPIs, performance metrics, and reporting requirements. Students shall develop a balanced scorecard, compare dashboards with scorecards, and present how cloud-based BI integrated with ERP systems can support strategic and operational decision-making.

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Course Articulation Matrix

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	2	1	1	1	–	–	–	1	1	–	1	3	2	1
CO2	3	3	2	2	1	–	–	–	1	–	1	2	3	2	2
CO3	3	3	3	2	2	–	–	–	1	–	1	2	3	3	2
CO4	3	3	3	2	3	–	–	–	1	1	1	2	3	3	2
CO5	2	3	2	2	3	1	–	–	1	2	1	3	2	3	3
Average	**2.8**	**2.8**	**2.2**	**1.8**	**2.0**	**0.2**	**0**	**0**	**1.0**	**0.8**	**0.8**	**2.0**	**2.8**	**2.6**	**2.0**

Text Books:

S. No.	Authors Name	Title	Edition	Publisher, Country	Year
1.	R.N. Prasad and Seema Acharya,	Fundamentals of Business Analytics	2nd Editon	Wiley India	2016
2.	Ramesh Sharda, Dursun Delen, Efraim Turban, David King	Business Intelligence. Analytics, and data science	4th Editon	Pearson	2022

Reference Books:

1. Negash, S., & Gray, P. (2018). *Business Intelligence*. Springer.
2. Golfarelli, M., & Rizzi, S. (2018). *Data Warehouse Design: Modern Principles and Methodologies* (2nd Edition). McGraw-Hill.

3. Loshin, D. (2019). *Business Intelligence: The Savvy Manager's Guide* (3rd Edition). Morgan Kaufmann.
4. Inmon, W. H. (2016). *Building the Data Warehouse* (5th Edition). Wiley.

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Course Name : **Internet Security**
Course Code : **TCS791**
Semester : **VII**
Pre-requisite : **Computer Networks-I (TCS514)**

L	T	P	Credits
3	0	0	3

Course Learning Objectives:

- To understand the architecture, addressing, and working principles of the Internet.
- To explain Internet security mechanisms, cyber threats, intrusion detection systems, and network scanning techniques.
- To apply cryptographic algorithms and security protocols for securing data and communication over networks.
- To analyze network security mechanisms, including VPNs, firewalls, tunneling, TLS/SSL, and common network attacks.
- To evaluate malware threats and implement appropriate monitoring, detection, and protection techniques for secure networked systems.

Course Outcomes:

After completion of the course, the students will be able to:

Course Outcome	Statement	Bloom's Level	Skill
CO1	Explain the architecture and working of the Internet.	L2 – Understand	Conceptual Understanding
CO2	Know the working of Internet security mechanisms.	L2 – Understand	Security Awareness
CO3	Use cryptographic techniques to secure Internet applications.	L3 – Apply	Cryptographic Implementation
CO4	Analyze various network security mechanisms.	L4 – Analyze	Network Security Analysis
CO5	Apply security mechanisms to protect networked systems from cyber threats.	L3 – Apply	Cybersecurity & Threat Mitigation

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Details of the Course:

Unit 1: Introduction and Overview **Contact Hours/Teaching Hours: 5**

Internet Architecture, How the Internet Works (high-level overview), IP address.

Self-Learning Hours = 6

Students shall explore the working of the Internet, understand IP addressing and DNS, and study the communication process between Internet hosts through online resources and practical demonstrations.

Team Activity Hours = 3

Group discussion and presentation on the architecture of the Internet, packet transmission process, and the role of various Internet protocols in real-world networking.

Unit 2: Internet Security Mechanisms

Contact Hours/Teaching Hours: 10

Denial-of-Service, Traceback, DoS Defence, Network Intrusion Detection Systems, Fundamental NIDS Issues, NIDS Evaluation, Scanning (NMAP, Nessus, NetTools, Smart Whois), Anonymity Tor browser

Self-Learning Hours = 6

Students shall study common Internet attacks, evaluate intrusion detection mechanisms, and explore the features of network scanning and anonymity tools through case studies and guided practice.

Team Activity Hours = 3

Group-based activity on identifying security vulnerabilities using network scanning tools and presenting suitable defence mechanisms against cyber threats.

Unit 3: Cryptography Basics and Applications

Contact Hours/Teaching Hours: 10

Secret Key encryption, DES, AES, One-way Hash functions, MD5, SHA-1 and SHA-2, collision attacks, Diffie-Hellman Key Exchange, Public-Key Encryption (RSA), Digital Signatures, Public-key Infrastructure (PKI).

Self-Learning Hours = 6

Students shall practice the concepts of encryption, hashing, digital signatures, and key exchange mechanisms through examples and cryptographic tools.

Team Activity Hours = 3

Group activity on comparing symmetric and asymmetric cryptographic algorithms and demonstrating secure communication using digital certificates and PKI.

Unit 4: Network Security Mechanisms

Contact Hours/Teaching Hours: 09

Ip Tunneling and SSH Tunneling, Virtual Private Networks, Firewalls, Bypassing Firewalls, Transport Layer Security (TLS/SSL), TLS Programming, Packet Sniffer (Wireshark), Man in the middle attack.

Self-Learning Hours = 6

Students shall study secure communication protocols, configure VPN and firewall concepts, and analyze network traffic using Wireshark.

Team Activity Hours = 3

Group exercise on capturing and analyzing network packets using Wireshark, followed by discussions on firewall configurations and secure communication techniques.

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Unit 5: Monitoring Systems over Network

Contact Hours/Teaching Hours: 08

Malware attacks, Virus, Worms, Trojans horse, ransomware, keylogger, spyware, bot, botnet, botnet detection, and intrusion detection techniques.

Self-Learning Hours = 6

Students shall study different types of malware, analyze botnet behaviour, and understand intrusion detection techniques through case studies and cybersecurity reports.

Team Activity Hours = 3

Case study and group presentation on recent cyber-attacks involving malware and botnets, including recommendations for monitoring, detection, and mitigation strategies.

Course Articulation Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	2	–	–	2	–	–	–	–	1	–	1	2	2	1
CO02	2	3	–	2	3	1	–	1	–	1	–	1	2	2	3
CO03	2	2	3	2	3	1	–	2	–	1	–	1	3	2	3
CO04	2	3	2	3	3	1	–	1	–	1	–	2	3	2	3
CO05	2	3	3	2	3	2	1	2	1	1	1	2	3	2	3
Avg.	2	3	3	2	3	1	1	2	1	1	1	1	3	2	3

Text Books:

1. William Stallings. Cryptography and Network Security. 7th McGraw Hill Education, American 2016
2. William Cheswick, Steven Bellovin, Aviel Rubin. Firewalls and Internet Security: Repelling the Wily Hacker (Addison-Wesley Professional Computing Series). 2nd Prentice Hall, American 2003

Reference Books:

1. William Stallings. Network Security Essentials: Applications and Standards 4thPrentice Hall, American 2011

Online Resources:

1. **GeeksforGeeks – Computer Networks & Network Security**
   https://www.geeksforgeeks.org/computer-network-tutorials/
2. **NPTEL – Computer Networks and Internet Protocol**
   https://nptel.ac.in/

3. **OWASP (Open Worldwide Application Security Project)**
   https://owasp.org/
4. **Wireshark Official Documentation**
   https://www.wireshark.org/docs/
5. **NIST Computer Security Resource Center (CSRC)**
   https://csrc.nist.gov/

Department of Computer Science and Engineering

B.Tech. Computer Science and Engineering

Course Name	:	**Advanced Computer Architecture**
Course Code	:	**TCS704**
Semester	:	**VII**
Pre-requisite	:	**Computer Organization (TCS-404)**

L	T	P	Credits
3	0	0	3

Course Learning Objectives:

- Develop an understanding of computer architecture fundamentals, technology trends, and performance evaluation techniques.
- Acquire knowledge of memory hierarchy design, cache organization, virtual memory, and memory optimization techniques.
- Understand pipelining concepts, RISC processor architecture, and pipeline performance issues in modern processors.
- Develop an understanding of branch prediction techniques, instruction-level parallelism, and processor optimization methods.
- Acquire knowledge of multiprocessor architectures and parallel processing models for high-performance computing systems.

Course Outcomes:

After completion of the course, the students will be able to:

Course Outcome	Statement	Bloom's Level	Skill
CO1	Explain the fundamentals of computer architecture, technology trends, performance metrics, benchmarking techniques, and performance evaluation laws.	L2 – Understand	Conceptual Understanding, Analytical Thinking
CO2	Analyse memory hierarchy, cache organization, cache optimization techniques, virtual memory, and address translation mechanisms for improving system performance.	L4 – Analyze	Memory Analysis, Performance Optimization
CO3	Analyse pipelining concepts, RISC pipeline architecture, pipeline performance, and pipeline hazards in modern processors.	L4 – Analyze	Processor Analysis, Problem Solving

CO4	Analyse branch prediction techniques, instruction-level parallelism, data dependencies, and register optimization methods for enhancing processor performance.	L4 – Analyze	Critical Analysis, Performance Optimization
CO5	Evaluate multiprocessor architectures, shared-memory and distributed-memory systems, and parallel processing models for high-performance computing applications.	L5 – Evaluate	System Evaluation, Parallel Computing Analysis

Details of the Course:

Unit 1: Fundamentals of Computer Architecture and Performance Evaluation
Contact Hours/Teaching Hours: 10

Fundamentals: Computer Architecture and Technology Trends, Moore's Law, Classes of Parallelism and Parallel Architectures, Instruction Set Architecture: The Myopic View of Computer Architecture, Trends in Technology, Trends in Cost, Processor Speed, Cost, Power, Power Consumption, Fabrication Yield Performance Metrics and Evaluation: Measuring Performance, Benchmark Standards, Iron Law of Performance, Amdahl's Law, Lhadma's Law.

Self-Learning Hours = 7

Students should study the fundamentals of computer architecture, understand the evolution of processor technology, analyze Moore's Law and technology trends, compare different parallel architectures, explore instruction set architectures, learn the impact of cost, power, and fabrication yield on processor design, and evaluate system performance using benchmark standards, the Iron Law of Performance, Amdahl's Law, and Lhadma's Law.

Team Activity Hours = 3

Students should work in teams to compare different computer architectures and parallel processing models, analyze benchmark results of modern processors, demonstrate the impact of performance metrics on system efficiency, and present case studies illustrating the application of Amdahl's Law and performance evaluation techniques.

Unit 2: Memory Hierarchy Design **Contact Hours/Teaching Hours: 9**

Memory Hierarchy Design: Basics of Memory Hierarchy, Coherence and Locality Properties, Cache Memory Organizations, Cache Performance, Cache Optimization Techniques, Virtual Memory, Techniques for Fast Address Translation.

Self-Learning Hours = 6

Students should study the organization of the memory hierarchy, understand locality and coherence properties, compare different cache organizations, analyze cache performance and optimization

techniques, explore virtual memory concepts, and learn fast address translation mechanisms for improving memory access efficiency.

Team Activity Hours = 3

Students should work in teams to analyze different cache organizations, demonstrate cache mapping techniques using examples, evaluate cache optimization methods, and present the role of virtual memory and address translation in enhancing system performance.

Unit 3: Pipelining **Contact Hours/Teaching Hours: 10**

Pipelining: What is Pipelining, Basics of a RISC ISA, The Classic Five-Stage Pipeline for a RISC Processor, Performance Issues in Pipelining, Pipeline Hazards.

Self-Learning Hours = 7

Students should study the concept of instruction pipelining, understand the RISC instruction set architecture, learn the operation of the five-stage pipeline, analyze pipeline hazards and performance issues, and explore techniques for improving instruction execution efficiency.

Team Activity Hours = 3

Students should work in teams to demonstrate instruction execution through a pipelined processor, identify different pipeline hazards, apply hazard resolution techniques, and present the performance improvements achieved through pipelining.

Unit 4: Branch Prediction and Instruction Level Parallelism **Contact Hours/Teaching Hours: 8**

Branches and Prediction: Branch Prediction, Direction Predictor, Hierarchical Predictors, If Conversion, Conditional Move. Instruction Level Parallelism: Introduction, RAW and WAW Dependencies, Duplicating Register Values, ILP.

Self-Learning Hours = 6

Students should study branch prediction techniques, understand direction and hierarchical predictors, explore conditional execution methods, analyze instruction dependencies, learn instruction-level parallelism concepts, and evaluate techniques for improving processor performance.

Team Activity Hours = 3

Students should work in teams to compare different branch prediction techniques, identify instruction dependencies in sample programs, demonstrate instruction-level parallelism using scheduling examples, and present methods for improving processor throughput.

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Unit 5: Multiprocessor Architecture **Contact Hours/Teaching Hours: 9**

Multiprocessor Architecture: Taxonomy of Parallel Architectures, Centralized Shared-Memory Architecture, Distributed Shared-Memory Architecture, Message Passing vs Shared Memory.

Self-Learning Hours = 6

Students should study the taxonomy of parallel architectures, understand centralized and distributed shared-memory systems, compare message-passing and shared-memory communication models, and evaluate their advantages, limitations, and applications in parallel computing environments.

Team Activity Hours = 3

Students should work in teams to compare different multiprocessor architectures, analyze the advantages and limitations of shared-memory and message-passing systems, prepare case studies on parallel computing applications, and present suitable architecture choices for different computing scenarios.

Course Articulation Matrix

Programme Outcomes / Course Outcome	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PO 07	PO 08	PO 09	PO 10	PO 11	PO 12	PSO 01	PSO 02	PSO 03
CO01	3	2	1	1	2					1		1	2	3	1
CO02	3	3	2	2	3							1	3	3	2
CO03	3	3	2	2	3							1	3	3	2
CO04	3	3	2	2	3					1		1	3	3	2
CO05	3	3	3	2	3			1		1		2	3	3	3
Avg	3	3	2	2	3			1		1		1	3	3	2

Text Books:

1. John L. Hennessy, David A. Patterson, “Computer Architecture: A Quantitative Approach” 5 th edition, Morgan Kaufmann ”by Kai Hwang ,“Advanced Computer Architecture”, McGraw Hill Publishing

Online Resources:

https://www.geeksforgeeks.org/computerarchitecture

Department of Computer Science and Engineering

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Course Name : **Multimodal AI**
Course Code : **TCS766**
Semester : **VII**
Pre-requisite : **NA**

L	T	P	Credits
3	0	0	3

Course Outcomes:

After completion of the course, the students will be able to:

Course Outcome	Statement	Bloom's Level	Skill
CO1	Define and explain the fundamental concepts, characteristics, and significance of multimodal AI and its applications.	**L2 – Understand**	Explain and Interpret
CO2	Analyze data fusion techniques and multimodal representation learning methods for effective integration of diverse modalities.	**L4 – Analyze**	Differentiate and Examine
CO3	Compare and contrast different machine learning architectures and pretrained models used for multimodal learning tasks.	**L4 – Analyze**	Compare and Differentiate
CO4	Evaluate and implement multimodal AI models for real-world applications in domains like healthcare, autonomous vehicles, and retail.	**L5 – Evaluate**	Evaluate and Implement
CO5	Design and propose novel multimodal AI solutions for complex engineering problems, considering scalability, ethics, and sustainability.	**L6 – Create**	Implement and Solve Problems

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Details of the Course:

Unit 1: Introduction to Multimodal AI, Data Fusion Techniques
Contact Hours/Teaching Hours: 10

Overview of multimodal AI systems, Significance and applications of combining multiple data types, Challenges in multimodal data processing: Early, late, and hybrid fusion techniques, Feature-level and decision-level fusion, Applications in enhancing model performance.

Unit 2: Multimodal Representations **Contact Hours/Teaching Hours: 08**

Creating joint representations from different modalities, Techniques like embedding and canonical correlation analysis, Case studies on effective representation learning

Unit 3: Multimodal Machine Learning Models **Contact Hours/Teaching Hours: 09**

Neural networks for multimodal learning, Use of transformers in multimodal contexts, Advanced models (Flamingo, ImageBind, DALL-E, GPT-4V), Integration of vision and language (ViLBERT, CLIP)

Unit 4: Applications of Multimodal AI **Contact Hours/Teaching Hours: 09**

Healthcare: Integrating medical imaging and textual reports, Retail: Combining customer behavior and sensory data, Autonomous Vehicles (sensor fusion), Multimodal Sentiment Analysis, and Multimodal Question Answering. Entertainment: Enhancing user experience through audio-visual data integration

Unit 5: Challenges and Future Directions **Contact Hours/Teaching Hours: 09**

Addressing disparities in modality dominance, Scalability and computational demands, Strategies to mitigate modality imbalance, Ethical considerations in multimodal AI applications

Course Articulation Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	2	1	-	-	-	-	-	-	-	-	2	2	1	-	2
CO02	2	2	2	1	-	-	-	-	-	-	1	2	2	1	2
CO03	1	2	1	2	2	-	-	-	-	-	1	2	2	2	1
CO04	2	2	2	3	3	2	-	-	-	-	2	3	3	2	2
CO05	2	3	3	2	2	3	-	-	-	1	3	3	3	3	2
Avg.	**1.8**	**2.0**	**2.0**	**2.0**	**2.33**	**2.5**	**-**	**-**	**-**	**1.0**	**1.8**	**2.4**	**2.2**	**2.0**	**1.8**

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

Text Books:

1. Ben Auffarth (2023), Generative AI with LangChain: Build Large Language Model (LLM) Apps with Python, ChatGPT and Other LLMs, 1st Edition, Packt Publishing, India.
2. Sinan Ozdemir (2023), Quick Start Guide to Large Language Models: Strategies and Best Practices for Using ChatGPT and Other LLMs, 1st Edition, Addison-Wesley Professional, USA.

Reference Books:

1. Lei Zhang, Shuai Wang, and Bing Liu (2023), Deep Learning for Multimodal Data, 1st Edition, CRC Press, USA.

GRAPHIC ERA HILL UNIVERSITY, DEHRADUN

SEMESTER VII

Name of Department: - Computer Science and Engineering

1. Course Code: **TCS762** Course Title: **NoSQL Database**
2. Contact Hours: **L:** 3 **T**: 0 **P**: 0
3. Examination Duration (Hrs): **Theory** 3 **Practical** 0
4. Relative Weight: **CIE** 25 **MSE** 25 **ESE** 50
5. Credits: 3
6. Semester: VII
7. Category of Course: DSC
8. Pre-requisite: Introduction to Big Data (TCS462), Big Data Analytics: Tools and Techniques (TCS 663)

9. **Course Outcome:**	After completion of the course the students will be able to**:** CO1: Demonstrate an understanding of the fundamental concepts, evolution, and aggregate-oriented data models of NoSQL databases, including Key-Value, Document, Column-Family, and Graph databases. CO2: Analyze distribution, replication, consistency, and scalability mechanisms used in NoSQL databases. CO3: Apply MapReduce and key-value database concepts for processing and managing large-scale data. CO4: Apply document database concepts to model, store, query, and manage semi-structured data for real-world applications. CO5: Evaluate Graph database concepts and their suitability for applications involving connected data, routing, location-based services, and recommendation systems.

10. **Details of the Course:**

Sl. No.	Contents	Contact Hours
1	**Unit 1:** Why NoSQL? The Value of Relational Databases, Getting at Persistent Data, Concurrency, Integration, A (Mostly) Standard Model, Impedance	10

	Mismatch, Application and Integration Databases, Attack of the Clusters, The Emergence of NoSQL. **Aggregate Data Models**: Aggregates, Example of Relations and Aggregates, Consequences of Aggregate Orientation, Key-Value and Document Data Models, Column-Family Stores, Summarizing Aggregate-Oriented Databases. **More Details on Data Models:** Relationships, Graph Databases, Schemaless Databases, Materialized Views, Modeling for Data Access	
2	**Unit 2**: **Distribution Models:** Single Server, Sharding, Master-Slave Replication, Peer-to-Peer Replication, Combining Sharding and Replication, Consistency, Update Consistency, Read Consistency, Relaxing Consistency, The CAP Theorem, Relaxing Durability, Quorums. Version Stamps, Business and System Transactions, Version Stamps on Multiple Nodes.	8
3	**Unit 3:** **Map-Reduce**: Basic Map-Reduce, Partitioning and Combining, Composing Map-Reduce Calculations, A Two-Stage Map-Reduce Example, Incremental Map-Reduce. **Key-Value Databases**: What Is a Key-Value Store, Key-Value Store Features, Consistency, Transactions, Query Features, Structure of Data, Scaling, Suitable Use Cases, Storing Session Information, User Profiles, Preference, Shopping Cart Data, When Not to Use, Relationships among Data, Multi-operation Transactions, Query by Data, Operations by Sets	9
4	**Unit 4:** **Document Databases**: What Is a Document Database?, Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Event Logging, Content Management Systems, Blogging Platforms, Web Analytics or Real-Time Analytics, E-Commerce Applications, When Not to Use, Complex Transactions Spanning	9

	Different Operations, Queries against Varying Aggregate Structures.	
5	**Unit 5:** **Graph Databases**: What Is a Graph Database?, Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Connected Data, Routing, Dispatch, and Location-Based Services, Recommendation Engines, When Not to Use	9
	Total	**45**

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Sadalage, P. & Fowler	NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence	1st	Pearson/Addison-Wesley, American	2012

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Dan Sullivan	NoSQL For Mere Mortals	1st	Pearson Education India	2015
Dan McCreary and Ann Kelly	Making Sense of NoSQL: A guide for Managers and the Rest of us	1st	Dreamtech Press, New Dehli	2013
Kristina Chodorow	Mongodb: The	2nd	O'Reilly,United	2013

	Definitive Guide- Powerful and Scalable Data Storage		Kingdom	