Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	**CS301**	**Title of the Course**	**Design and Analysis of Algorithm**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**V**	**3**	**0**	**2**	**4**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	To analyze the problem and design an efficient algorithm to solve it by using & modifying classical design techniques or creating a new solution technique						

Course Outcomes	
CO1	Analyze algorithm efficiency using asymptotic notations and recurrence solving techniques to evaluate growth functions.
CO2	Apply divide and conquer techniques to implement efficient sorting algorithms and advanced data structures for optimized performance.
CO3	Develop optimal solutions using greedy and dynamic programming techniques for combinatorial optimization and shortest path problems.
CO4	Describe amortized analysis techniques to understand algorithm efficiency and design advanced algorithmic solutions using backtracking and branch & bound techniques for complex optimization problems.
CO5	Analyze string matching algorithms and computational complexity classes to classify problems based on their solvability and efficiency.

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction:**	Introduction: Algorithms, Analysis of Algorithms, Growth of Functions: Asymptotic Notations, Standard Notations and Common Functions; Recurrence Methods: Substitution Method, Iteration Method, Recursion Tree Method, Master's Method. Application of recurrence relations in optimizing computing resources.	7	1
2	**Designing of Algorithms and Advanced Data Structure**	Divide & Conquer: Heap Sort, Quick Sort, Sorting in Linear Time, Medians and Order Statistics. Red-Black Trees, Augmenting Data Structure, Binomial Heaps, Fibonacci Heaps.	6	2
3	**Advanced Design and Analysis Techniques**	Greedy Algorithms: Knapsack Problem, Travelling Salesperson Problem, Minimum Cost Spanning Trees: Kruskal's Algorithm, Prim's Algorithm. Dynamic Programming: Longest Common Subsequence, Matrix Chain Multiplication, 0/1 Knapsack Problem, Single Source Shortest Path: Dijkstra's Algorithm, Bellman Ford Algorithm.	7	3
4	**Amortized Analysis, Back Tracking: and Branch & Bound**	Amortized Analysis: Accounting Method, Aggregate Method, Potential Method, Back Tracking: Introduction, Subset Sum Problem, Case Study- n-Queens problem Branch & Bound: Introduction, Case study - 0/1 Knapsack, 15 Puzzle problem.	7	4
5	**String Matching and Complexity Theory**	Algorithm, The Rabin-Karp Algorithm, The Knuth-Morris Pratt Algorithm. Class P and NP, NP-hard Problems, NP-Complete Problems, Polynomial Reduction, Approximation Algorithm	6	5

PRACTICAL

S. No	List of Experiments	Contact Hrs.	Mapped CO
1	Implement the Fibonacci sequence using both recursive, non-recursive approach and analyze their time complexity.	2	1
2	Execute MergeSort using the divide and conquer approach and analyze its time complexity.	2	1
3	Execute QuickSort using the divide and conquer approach and compare its efficiency with MergeSort under varying input conditions, including best, worst, and average cases.	2	2
4	Design and execute HeapSort to demonstrate priority queue operations.	2	2
5	Design and implement greedy algorithms to solve the Fractional Knapsack problem.	2	3
6	Implement and analyze Dijkstra's Algorithm to determine the shortest path in weighted graphs with non-negative edges under varying graph densities.	2	3
7	Execute Kruskal's Algorithm to construct a Minimum Spanning Tree (MST) and visualize using online tools also justify the usage of tools considering various factors.	2	3
8	Execute Prim's Algorithm to construct a Minimum Spanning Tree (MST) and compare its performance with Kruskal's Algorithm under varying graph densities and edge weights.	2	3
9	Design and execute the solution for 8-Queens problem using backtracking.	2	4
10	Execute the implementation of the π (prefix) function in the Knuth-Morris-Pratt (KMP) string matching algorithm and analyze its role in optimizing pattern searches for a given input string: "ABABAC"	2	5

Reference Books:

1. Coremen, Rivest, Lisserson, "Algorithms", PHI.
2. Horwitz & Sahani, Fundamental of Computer Algorithm, Galgotia.
3. Michael T. Goodrich and Roberto Tamassia, Algorithm Design: Foundation, Analysis and Internet Examples, John Wiley Publications.

e-Learning Source:

https://nptel.ac.in/courses/106106131

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2				1					1	1	2	3
CO2	2		2	2								2	1	2
CO3	3		2	2	2							1	1	3
CO4	2	3	1	1								1		2
CO5	1	2		1							1	2		3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	**CS315**	**Title of the Course**	**Compiler Design**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**VI**	**4**	**0**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	1. To understand the concepts of compiler, its phases and passes, finite state machines, regular expressions, and their application to lexical analysis. 2. To learn context free grammar, parsing techniques including top-down and bottom-up parsing, and the automatic construction of efficient parsers. 3. To understand syntax-directed translation schemes, intermediate code generation, and their implementation using parse trees and three-address code. 4. To study symbol table data structures, runtime administration, and storage allocation schemes in block-structured languages. 5. To understand code optimization techniques including loop optimization, DAG representation, global data-flow analysis, and code generation algorithms.						
Course Outcomes							
CO1	Recall and understand the concepts of a preprocessor, translation rules, cross compiler, assembler, loader, and linker and the working of finite state machines and regular expressions in lexical analysis.						
CO2	Apply and analyze the basic principles of context free grammars, parsing techniques including predictive parsers, LL(1), shift-reduce parsing, and operator precedence parsing to design efficient syntax analyzers.						
CO3	Construct and evaluate LR, SLR, Canonical LR, and LALR parsing tables, and understand the function and complexity of modern compilers in translating high-level programs to machine code.						
CO4	Understand and implement syntax-directed translation schemes, intermediate code generation using three-address code, quadruples and triples, and code generation algorithms to produce optimized machine code.						
CO5	Design and Analyze flow graphs, apply machine-dependent and machine-independent optimizations, perform global data-flow analysis, and understand symbol table structures and runtime storage allocation.						

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction**	Introduction to Compiler, Phases and Passes, Bootstrapping, Finite State Machines and Regular Expressions and their Applications to Lexical Analysis, Implementation of Lexical Analysers, Lexical Analyser Generator, LEX-compiler, Formal Grammars and their Application to Syntax Analysis, BNF Notation, Ambiguity, YACC.	8	1
2	**Context Free Grammars**	The Syntactic Specification of Programming Languages: Context Free Grammars, Derivation and Parse Trees, Capabilities of CFG. Basic Parsing Techniques: Parsers, Top Down Parsing, Predictive Parsers, LL(1), Shift Reduce Parsing, Operator Precedence Parsing, Elimination of Left Recursion.	8	2
3	**Parsing**	Automatic Construction of Efficient Parsers: LR Parsers, the Canonical Collection of LR(0) Items, Constructing SLR Parsing Tables, Constructing Canonical LR Parsing Tables, Constructing LALR Parsing Tables, Using Ambiguous Grammars, an Automatic Parser Generator, Implementation of LR Parsing Tables, Constructing LALR Sets of Items.	8	3
4	**Syntax-Directed Translation**	Syntax-Directed Translation: Syntax-Directed Translation Schemes, Implementation of Syntax-Directed Translators, Intermediate Code, Postfix Notation, Parse Trees & Syntax Trees, Three Address Code, Quadruple & Triples, Translation of Assignment Statements, Boolean Expressions, Statements that Alter the Flow of Control, Postfix Translation, Translation with a Top-Down Parser. More About Translation: Array References in Arithmetic Expressions, Procedures Call, Declarations, Case Statements.	8	4
5	**Symbol Tables & Code Optimization**	Symbol Tables: Data Structure for Symbol Tables, Representing Scope Information. Run-Time Administration: Implementation of Simple Stack Allocation Scheme, Storage Allocation in Block Structured Language. Introduction to Code Optimization: Loop Optimization, the DAG Representation of Basic Blocks, Value Numbers and Algebraic Laws, Global Data-Flow Analysis. Introduction to Code Generation.	8	5

Reference Books:

1. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, "Compilers: Principles, Techniques and Tools" (Dragon Book), Addison Wesley, 2nd Edition.
2. Kenneth C. Louden, "Compiler Construction: Principles and Practice", Cengage Learning.
3. D.M. Dhamdhere, "Compilers: Principles and Practice", Macmillan India.
4. Andrew W. Appel, "Modern Compiler Implementation in C", Cambridge University Press.

e-Learning Source:

1. https://onlinecourses.nptel.ac.in/noc21_cs07/preview
2. https://nptel.ac.in/courses/106/108/106108052/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)																
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2	2	3	3	3	3						3	3		
CO2	2	2	3	2		1							3	2	3	
CO3	1	3	2	3		2							1	2	3	
CO4	3	3	3	3		2							3	3	3	
CO5	3	3	3	3		3			1				2	3	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective Session: 2026-27 (NEP)							
Course Code	CS305	**Title of the Course**	COMPUTER NETWORK	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	4	0	2	5
Pre-Requisite	None	**Co-requisite**	None				

Course Objectives

1. To inculcate the conceptual & practical knowledge of computer networking right from "Basic" to a "Higher-Level understanding" of the course.
2. Helping to acquire the know-how of designing & organization computer networks, understanding the communication process and use of networking devices.
3. Imparting knowledge of Network Models, its working principles and functioning of various protocols associated thereto.
4. Enabling students to gain the practical knowledge of designing efficient networks, its implementation, monitoring and troubleshooting of computer network

Course Outcomes

CO1	**Recall** and **understand** communication and networking fundamentals, such as "Network Design, its Types, Transmission Media, Switching Techniques, Networking Devices, and OSI & TCP/IP Models".
CO2	**Understand** & **Analyze** Error Control, Flow Control, & Access Control Mechanisms and **Apply** Appropriate Methods/Measures to **Resolve** Relevant Issues for Fast & Efficient Data Link Layer Operations.
CO3	**Analyze** and **Assess** Routing Algorithms & IP Addressing mechanisms to **Design, Create** and **Develop** networks/sub-network using IP addressing concepts and **Implement** routing algorithms through modern simulation tools.
CO4	**Implement** & **Evaluate** TCP and various congestion control techniques, differentiate connectionless and connection-oriented services, and **apply** flow control techniques to assess and analyze network performance.
CO5	**Recognize** and **Analyze** Factors Influencing Network Performance, **Assess** Quality of Service, and **Resolve** Issues Using Various Application Layer Protocols.

THEORY

S. No.	Title of the Units	Content of Unit	Contact Hrs.	Mapped CO
1	**Basics of Network & Physical Layer**	**Computer Network:** Basic Communication Model, Data representation, Modes of Communication, Performance Criteria, Topologies, Types of Network, OSI Layered Architecture, TCP/IP protocol suite. **Physical Layer:** Transmission Media- **Guided Media**: Twisted Pair Cable, Coaxial Cable, Fiber Optics, **Unguided Media**: Radio Waves, Microwaves & Infrared Waves. Switching Techniques: Circuit switching, Message Switching, Packet Switching, **Network Devices**: Repeater, Hub, Switch, Bridge, Router and Gateway.	9	1
2	**Data Link Layer**	**Error Control:** Types of Error, Block Coding- Error Detection: Linear Block Codes, Cyclic Codes, Error Correction: Hamming Code. **Flow control:** Stop & Wait, Sliding Window Protocols: Functioning and Implementation of SW-Protocols- Go-Back-N ARQ, Selective Repeat ARQ. **Access Control:** Random Access methods- ALOHA, CSMA, CSMA/CD. Channelization- FDMA, TDMA, CDMA. Overview of Fast Ethernet, FDDI.	8	2
3	**Network Layer**	**IP Addressing:** Classfull Addressing, net-id, hosted, mask, subnet. Classless addressing, Subnetting using Classless Addressing, IPv4 Addressing, Datagram Formats for IPv4 and IPv6 addresses. **Routing:** Packet delivery and packet forwarding. **Unicast Routing:** Distance Vector Routing-RIP and Link State Routing-OSPF, Path Vector Routing-BGP **Address Mapping Protocols:** ARP and RARP.	9	3
4	**Transport Layer**	**Transport Layer Services:** Process To Process Delivery, Connectionless Versus Connection Oriented Services, UDP Services & Frame Format. **Transmission Control Protocol:** TCP Services & Segment Format, TCP Connection Establishment & Termination Process. **Congestion Control Techniques**: Open Loop Techniques- Retransmission, , Admission Control, Acknowledgement Policy, Discard Policy & Traffic Shaping. Closed Loop Techniques- Choke Packet, Back Pressure, Implicit & Explicit Signaling.	7	4
5	**Quality of Service**	**Network Criteria:** Performance, Reliability, Security, Jitter. **Traffic Scheduling**: FIFO Technique, Weighted Fair Queuing. **Traffic Shaping:** Leaky Bucket, Token Bucket. **Application Layer:** Domain Name System: Name Space, DNS, Distribution of Domain Name Space. **E-Mail Protocol**: SMTP, IMAP, POP3. **File Transfer:** FTP. Telnet, WWW Architecture, Client-Server, URL, Cookies, Firewall.	7	5

PRACTICAL

S.No	List of Experiments	Contact Hrs.	Mapped CO
1	Simulation of Basic Router Configuration in cisco packet tracer	**2**	**1**
2	Simulation of Router Name and Password in cisco packet tracer	**2**	**1**

3	Simulation of Banner mold and login in Cisco packet tracer	**2**	**2**
4	Simulation of telnet in Cisco packet tracer	**2**	**2**
5	Simulation of DHCP in Cisco packet tracer	**2**	**3**
6	Simulation of RIP in cisco packet tracer	**2**	**3**
7	Simulation of OSPF in cisco packet tracer	**2**	**4**
8	Simulation of crate and add VLAN in cisco packet tracer	**2**	**4**
9	Simulation of STP in cisco packet tracer	**2**	**5**
10	Simulation of two router communication in cisco packet Tracer	**2**	**5**

Reference Books:

1. *Forouzan, "Data Communication and Networking", TMH*
2. *A.S.Tanenbaum, "Computer Networks", 3rd Edition,Prentice Hall India,1997*
3. *W. Stallings, "Data and Computer Communication", Macmillan Press,1989.*

e-Learning Resources:

NPTEL Video Lecture by Dr. Neminath Hubballi (IIT Indore) - Advance Computer Network

NPTEL Video Lecture by Prof. Ajit Pal (IIT Kharagpur)

NPTEL Video Lecture by Prof. Hema A Murthy (IIT Madras)

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO /CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1		1						1	2	1	3
CO2	3	2	2	2	2						1	1	3	1
CO3	3	2	3	2	3	1		1			1	3	1	2
CO4	2	1	2	1	2			1			1	1	2	1
CO5	2	1	1		1			1			2	2	1	2

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	CS394	**Title of the Course**	Artificial Intelligence Analyst	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**4**	**0**	**2**	**5**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To understand the different phases of Artificial Intelligence on cloud platforms. • To learn data exploration and data understanding techniques for working with datasets. • To understand data preparation and data conversion methods for AI applications. • To learn how to use different data visualization charts and understand their characteristics. • To get an introduction to machine learning algorithms and estimators for building models.						

Course Outcomes	
CO1	Define the foundational concepts of Artificial Intelligence.
CO2	Identify the steps involved in preprocessing and analyzing data for AI applications.
CO3	Use popular AI tools and frameworks such as TensorFlow, PyTorch, scikit-learn, and Keras to develop AI solutions.
CO4	Analyze real-world applications of AI across industries such as healthcare, finance, retail, and autonomous systems to understand their use and impact.
CO5	Evaluate the rapid evolution of Artificial Intelligence and develop a mindset of continuous learning and adaptation.

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction To Artificial Intelligence:**	A comprehensive overview of AI concepts and applications, discussing the various types of AI and the need to transition towards its adoption. It explores the historical development and current trends in AI, highlighting IBM's significant contributions throughout its evolution. Students will learn about the different stages of AI history and their implications. Additionally, the unit emphasizes the ethical considerations and societal impacts of AI, showcasing its influence on the real world and examining real-time applications in various industries.	8	1
2	**Python for Artificial Intelligence:**	It begins with an introduction to Python, covering its features, variables, data types, and syntax. Students will gain a solid understanding of object-oriented programming (OOP) concepts, including functions, classes, and objects. The unit also explores key Python libraries such as Pandas, NumPy, Matplotlib, scikit-learn, and Keras, providing foundational knowledge for AI programming.	8	2
3	**Machine Learning and training of AI:**	This unit focuses on the relationship between machine learning and AI, explaining the process of transforming a regular machine into a smart machine using machine learning techniques. Students will explore various types of machine learning algorithms, including supervised learning, unsupervised learning, reinforcement learning, and ensemble learning, with hands-on implementation using Python.	8	3
4	**Deep Learning and Training of AI:**	Deep learning and its distinctions from machine learning and AI. Topics include neural networks and their various types, as well as algorithms such as recurrent neural networks (RNNs) with their implementation in Python. Key concepts like activation functions, bias, weights, backpropagation, and the vanishing gradient problem are also covered. The unit explores long short-term memory (LSTM) networks and convolutional neural networks (CNNs), detailing pooling, padding, fully connected layers (FCLs), and their implementation using Python and Keras.	8	4
5	**AI services by IBM tools:**	AI-powered tools for text-to-speech and speech-to-text conversions. Additionally, the unit focuses on building virtually powered chatbots integrated with AI assistants. By leveraging IBM Cloud services, students will gain hands-on experience in developing AI-driven solutions, preparing them for industry demands.	8	5

PRACTICAL

S. No.	List of Experiments	Contact Hrs.	Mapped CO
1	Introduction to IBM cloud services	2	1
2	To study text to speech conversion using Watson AI	2	1
3	To study speech to text conversion using Watson AI	2	1
4	Data preparation and conversion using python (pandas).	2	2
5	To study about different types of visualization graph using data refinery visualization features and EDA in python programming.	2	2
6	To study about different ML algorithms/estimators using sci-kit learn.	2	3
7	Introduction to IBM Watson assistant.	2	3
8	Build a live AI powered chat-bot for websites.	2	4
9	Deploying IBM Watson assistant chat-bot.	2	4
10	Creating prediction models using python and sci-kit learn.	2	5

11	Creating classification models using python and sci-kit learn.	2	5

Reference Books:

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. Jake VanderPlas, Python Data Science Handbook: Essential Tools for Working with Data, O'Reilly Media.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1		2	3	1	1
CO2	3	2	2	1	3	1	1		1	1		3	3	2
CO3	3	3	2	2	3	2	2	1		1	1	3	3	2
CO4	3	3	2	2	3			2		1		3	3	2
CO5	2	2	3	2	3	1	1	1	1		3		3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 **(NEP)**							
Course Code	**CS334**	**Title of the Course**	**Cloud Computing**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**V**	**3**	**0**	**0**	**3**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	The course aims to provide an in-depth understanding of various paradigms and computing techniques in cloud computing. It explores the key concepts, technologies, strengths, limitations, and potential applications of cloud computing. Students will gain knowledge of the architecture and infrastructure of cloud computing, including models such as SaaS, PaaS, IaaS, and deployment options like public, private, and hybrid clouds. The course focuses on interpreting data, understanding scalability, and leveraging cloud services to achieve efficient database management for cloud storage.						

Course Outcomes

CO1	Understand and explain the paradigms of cloud computing and different computing techniques.
CO2	Analyze and articulate the concepts, key technologies, strengths, limitations, and potential applications of cloud computing.
CO3	Identify and evaluate the architecture and infrastructure of cloud computing, including SaaS, PaaS, IaaS, and deployment models such as public, private, and hybrid clouds.
CO4	Interpret data, scalability, and various cloud services to optimize database efficiency for cloud storage.
CO5	Recommend and justify suitable cloud computing solutions for specific applications, considering efficiency and scalability.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Introduction:	Historical development, Vision of Cloud Computing, Characteristics of cloud computing as per NIST, Cloud computing reference model, Cloud computing environments, Cloud services requirements, Cloud and dynamic infrastructure. Overview of cloud applications: ECG Analysis in the cloud, Protein structure prediction, Gene Expression Data Analysis, Satellite Image Processing, CRM and ERP, Social networking.	7	1
2	Cloud Computing Architecture:	Cloud Reference Model, Types of Clouds, Cloud Interoperability & Standards, Scalability and Fault Tolerance; Cloud Solutions: Cloud Ecosystem, Cloud Business Process Management, Cloud Service Management. Cloud Offerings: Cloud Analytics, Virtual Desktop Infrastructure.	7	2
3	Cloud Management & Virtualization Technology:	Resiliency, Provisioning, Asset management, Concepts of Map reduce, Cloud Governance, High Availability and Disaster Recovery. Virtualization: Fundamental concepts of compute, storage, networking, desktop and application virtualization. Virtualization benefits, server virtualization, Block and file level storage virtualization Hypervisor management software, Infrastructure Requirements, Virtual LAN(VLAN) and Virtual SAN(VSAN) and their benefits.	7	3
4	Cloud Security:	Cloud Information security fundamentals, Cloud security services, Design principles, Secure Cloud Software Requirements, Policy Implementation, Cloud Computing Security Challenges, Virtualization security Management, Cloud Computing Security Architecture.	6	4
5	Market Based Management of Clouds, Federated Clouds/Inter Cloud:	Characterization & Definition, Cloud Federation Stack, Third Party Cloud Services. Case study: Google App Engine, Microsoft Azure, Hadoop, Amazon.	6	5

Reference Books:

1. Buyya, Selvi ," Mastering Cloud Computing ",TMH Pub.
2. Kumar Saurabh, "Cloud Computing" , Wiley Pub.
3. Krutz , Vines, "Cloud Security " , Wiley Pub.
4. Velte, "Cloud Computing- A Practical Approach" ,TMH Pub.
5. Sosinsky, "Cloud Computing" , Wiley Pub.

e-Learning Source:

https://nptel.ac.in/courses/106105196

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
PO1	2	3	1	1	-	-	-	-	-	-	-	2	-	2
PO2	2	3	1	2	-	-	-	-	-	-	-	2	-	2
PO3	1	2	3	1	-	-	-	-	-	-	-	2	-	2
PO4	1	2	2	1	-	-	-	-	-	-	-	1	-	2
PO5	1	2	2	1	-	-	-	-	-	-	-	2	-	1
PO6														

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	**CS341**	**Title of the Course**	**Introduction to Internet of Things**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**VI**	**3**	**0**	**0**	**3**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	To introduce the fundamental concepts, architecture, and design principles of the Internet of Things (IoT). To impart knowledge of IoT communication models, protocols, and access technologies. To enable students to understand IoT system management, M2M communication, and virtualization techniques. To provide practical exposure to IoT devices such as Arduino and Raspberry Pi, focusing on interfacing and programming. To develop skills in cloud integration, data analytics, and IoT security for real-world applications.						

Course Outcomes	
CO1	Recall and explain the fundamental concepts of IoT including its definition, characteristics, physical and logical design, architectures, functional blocks, communication models, APIs, and challenges.
CO2	Identify and analyze IoT communication protocols, wireless medium access issues, routing protocols, sensors, actuators, smart objects, and IoT access technologies to evaluate their role in IoT networks.
CO3	Apply and assess IoT system management concepts including SDN, NFV, NETCONF, YANG, and SNMP to differentiate approaches and implement basic IoT management solutions.
CO4	Design and implement IoT applications using Arduino and Raspberry Pi by programming interfaces (serial, SPI, I2C), integrating external gadgets, controlling outputs, and reading inputs.
CO5	Evaluate and develop IoT solutions using cloud storage models, web servers, communication APIs, data analytics tools, and security mechanisms to address advanced IoT challenges.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to IoT**	Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Comparing IoT Architectures , Functional blocks of IoT, Communication models & APIs, IoT Challenges.	6	1
2	**Communication Protocols**	Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensors, Actuators and Smart Objects, Sensor Networks, Connecting Smart Objects, IoT Access Technologies.	7	2
3	**IoT and M2M**	Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER	7	3
4	**IoT Physical Devices and Endpoints**	Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C), Programming – Python program with Raspberry PI focusing on interfacing external gadgets, controlling output, reading input from pins.	7	4
5	**IoT Physical Servers and Advanced Topics**	Introduction to Cloud Storage models and communication APIs, Web server – Web server for IoT, Cloud for IoT, An Introduction to Data Analytics for IoT, Big Data Analytics Tools and Technology, Securing IoT, Common Challenges in IoT Security	6	5

Reference Books:

1- Raj Kamal, "Internet of Things: Architecture and Design Principles", **Standard** Edition, McGraw Hill Education, 2022.

2- Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015.

3- David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT, 20217

Program Articulation Matrix (PAM)

PO- PSO **CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	-	-	-	-	-	-	3	2	-
CO2	2	3	2	2	2	-	-	-	-	-	-	2	3	-
CO3	3	2	3	2	2	-	-	-	-	-	-	3	3	2
	2	3	2	3	2	-	2	-	-	-	-	2	2	2
CO5	3	2	3	2	3	-	-	2	-	-	2	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27(NEP)							
Course Code	CS345	**Title of the Course**	Advance Computer Architecture	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	3	0	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	1. Understand the evolution of computer architecture and the impact of parallel processing on performance. 2. Analyze the principles of pipelining, instruction-level parallelism, and scheduling mechanisms in modern processors. 3. Apply various processor architectures, including superscalar, vector, and VLIW architectures, to optimize computational efficiency. 4. Evaluate the role of synchronous parallel processing in SIMD Architectures and their applications in high-performance computing. 5. Demonstrate knowledge of interconnection networks and their significance in multi-processor communication and data transfer.						
Course Outcomes							
CO1	Explain fundamental concepts of computer architecture, including performance evaluation, parallel processing, and classification schemes.						
CO2	Analyze pipeline processing, instruction-level parallelism, and hazard detection mechanisms to improve execution efficiency.						
CO3	Apply different processor architectures (Superscalar, Vector, VLIW) and memory technologies for optimized computing.						
CO4	Evaluate SIMD architecture, parallel algorithm design, and data mapping techniques in high-performance systems.						
CO5	Design and assess interconnection networks, including crossbar and shuffle-exchange networks, for efficient communication in multi-processor environments.						

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction**	Introduction to Computer Architecture, Evolution of Computer Architecture, Parallel Computing, Parallel Architectural Classification Schemes: Flynn's, Shores, Feng's Classification; Performance of Parallel Processors: Speedup Performance Laws, Amdahl Law, and Gustafson Law, Performance metrics and measures.	**7**	**1**
2	**Pipeline Processing:**	Pipeline Processing: Introduction to Pipeline Processing, Arithmetic Pipelines, Pipelined Instruction Processing, Instruction Level Parallelism, Interlocks, Hazards, and Hazards Detention & Resolution, Scheduling of Pipelines.	**6**	**2**
3	**Processor Architectures**	Processor Architectures: Superscalar Architecture, Vector Architecture and VLIW Architecture, Super pipeline design, Memory Technology: Cache Architecture; Cache Coherence and Synchronization Mechanisms, Shared-Memory Organizations.	**7**	**3**
4	**Synchronous parallel processing**	Synchronous parallel processing, SIMD Architecture, and programming principles, SIMD parallel algorithm, Data mapping and memory in Array Processor	**6**	**4**
5	**Interconnection Network**	Interconnection Network, introduction to permutations, group of mapping, decomposition of a permutation into cycles, elementary permutation used in interconnection network, complete non-blocking network, cross-bar network, clos network, Bens's network, shuffle exchange network.	**7**	**5**

Reference Books:

1. Peterson & Heresy, "Quantitative Approach to computer Architecture"
2. Kai Hwang, "Advance Computer Architecture", McGraw Hill International
3. Morris Mano, "Computer System Architecture"
4. Bhujde, "Parallel Computing", New Age International

e-Learning Source:

Program Articulation Matrix (PAM)														
PO-PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	2	2	1	1	1	2	1	2	3	1	1
CO2	3	3	2	3	2	1	1	1	2	2	2	3	2	2
CO3	2	3	3	3	3	1	1	1	2	3	2	3	3	3
CO4	3	3	3	3	3	2	1	2	2	3	2	3	3	3
CO5	3	3	3	3	3	2	1	2	3	3	2	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27(NEP)							
Course Code	**CS320**	**Title of the Course**	**Real Time System**	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	3	0	0	3
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	1. To give knowledge and understandings of Real time Systems and their applications.						
Course Outcomes							
CO1	Identify and understand the concepts of operating systems and their application in real-time systems, including tasks and scheduling.						
CO2	Compare and analyze the various parameters related to the different types of scheduling in single processor and multiprocessor environments.						
CO3	Understand, apply, and analyze the concepts of real-time databases and their practical applications.						
CO4	Apply the basic concepts of fault tolerance and clocks to design an effective real time system.						
CO5	Identify, understand, apply, analyze, and evaluate protocols for effective resource sharing in real-time environments.						

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction:**	Introduction to Real Time Systems, Structure of Real Time System, Various Classification of Real Time Systems, Embedded System, Characterizing Real Time System & Task, Various Issues in Real Time System	**6**	**1**
2	**Task Assignment & Scheduling**	Classical Uniprocessor Scheduling Algo- Rate Monotonic, EDF. Uniprocessor Scheduling of IRIS Tasks, Identical and Nononidentical Linear & Concave Reward Function, 0/1 Reward Function. Task Assignment Algorithms- Utilization Balancing, A Next-Fit Algorithm for RM Scheduling, A Myopic Offline Scheduling FAB Algorithm & Buddy Strategy	**7**	**2**
3	**Real Time Database**	Real Time vs. General purpose Database, Main Memory database, Concurrency Control Issues, Real Time OS- Threads and Tasks, Kernel, Case Study of QNX, VRTX, Vx Works.	**6**	**3**
4	**Fault Tolerance Techniques**	Introduction Fault, Fault Detection and Error Containment, Redundancy Data Diversity, Reversal Checks, Malicious & Integrated Failure Handling. Clock Synchronization: Introduction Clocks, A Nonfault Tolerant Synchronization Algorithms, Impact of Fault, Fault Tolerant Synchronization in H/Wand S/W	**7**	**4**
5	**Real Time Communication**	Introduction, N/W Topologies, Protocols: Internet & Resource Reservation Protocols, Real Time Protocol, Contention-Based Protocol.	**6**	**5**

Reference Books:

1. C.M. Krishna & Shin. “Real Time Systems”, Mc Graw Hill 1985.
2. Jane W.S. LIU, “Real Time Systems”, Pearson Education.
3. Levo & Agarwal, “Real Time Systems”, Mc Graw Hill.

e-Learning Source:

https://onlinecourses.nptel.ac.in/noc21_cs98/preview

https://www.coursera.org/learn/real-time-systems

Program Articulation Matrix (PAM)														
PO-PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1		1					2	2	2	2	3	2
CO2	3	3	3	3	3						2	2	3	2
CO3	3	3			3				2		3	3	3	
CO4	3	3	3		2						3	3	2	2
CO5	3	3			1				2		3	2		2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-2027 (NEP)							
Course Code	**CS312**	**Title of the Course**	**Digital Image Processing**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**V**	**3**	**0**	**0**	**3**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	• To introduce the fundamentals of image processing, including motivation, applications, visual perception, image models, and basic operations such as sampling and quantization. • To explore various image enhancement techniques, including spatial domain filtering, histogram processing, arithmetic operations, and color transformations • To study image registration and feature extraction methods, covering geometric transformations, stereo imaging, topological and geometric attributes. • To introduce advanced image processing algorithms for face detection and recognition						
Course Outcomes:							
CO1	Describe fundamental concepts of image processing, including enhancement, segmentation, and morphological operations.						
CO2	Apply image processing techniques such as filtering, edge detection, and color transformations to solve computational problems.						
CO3	Analyze and evaluate image registration, feature extraction, and segmentation algorithms for effective image representation.						
CO4	Implement object recognition techniques using classification, clustering, and syntactic recognition methods.						
CO5	Design and develop real-world applications utilizing existing image processing algorithms and tools.						

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction and Fundamentals**	Motivation and Perspective, Applications, Components of Image Processing System, Element of Visual Perception, A Simple Image Model, Sampling and Quantization.	6	1
2	**Image Enhancement in Spatial Domain**	**Introduction**; Basic Gray Level Functions – Piecewise-Linear Transformation Functions: Contrast Stretching; Histogram Specification; Histogram Equalization; Local Enhancement; Enhancement using Arithmetic/ Logic Operations – Image Subtraction, Image Averaging; Basics of Spatial Filtering; Smoothing - Mean filter, Ordered Statistic Filter; Sharpening – The Laplacian.	7	2
3	**Color Image Processing**	Color Fundamentals, Color Models, Converting Colors to different models, Color Transformation, Smoothing and Sharpening, Color Segmentation. **Morphological Image Processing:** Introduction, Logic Operations involving Binary Images, Dilation and Erosion, Opening and Closing, Morphological Algorithms – Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening.	8	3
4	**Registration**	Introduction, Geometric Transformation – Plane to Plane transformation, Mapping, Stereo Imaging – Algorithms to Establish Correspondence, Algorithms to Recover Depth Segmentation Introduction, Region Extraction, Pixel-Based Approach, Multi-level Thresholding, Local Thresholding, Region-based Approach, Edge and Line Detection: Edge Detection, Edge Operators, Pattern Fitting Approach, Edge Linking and Edge Following, Edge Elements Extraction by Thresholding, Edge Detector Performance, Line Detection, Corner Detection.	8	4
5	**Feature Extraction**	Representation, Topological Attributes, Geometric Attributes. Description Boundary-based Description, Region based Description, Relationship. **Object Recognition:** Deterministic Methods, Clustering, Statistical Classification, Syntactic Recognition, Tree Search, Graph Matching	8	5

Reference Books:

1. Digital Image Processing 2nd Edition, Rafael C. Gonzalez and Richard E. Woods. Published by: Pearson Education.
2. Digital Image Processing and Computer Vision, R.J. Schalkoff. Published by: John Wiley and Sons, NY.
1. Fundamentals of Digital Image Processing, A.K. Jain. Published by Prentice Hall, Upper Saddle River, NJ.

e-Learning Source:

https://nptel.ac.in/courses/106106131

Program Articulation Matrix														
PO- PSO / CO	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO 1	2	1	3	1	1	3	1	2	1	1	2	3	2	
CO 2	3	2	3	2	1	1			2		2	1	3	
CO 3	2	2	1	1	2	2	3		1		3			3
CO 4	3	2	2	2	3	3					2			3
CO5	3	1	1	1	1	2	1				2			3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session:2026-27 (NEP)							
Course Code	CS346	**Title of the Course**	Concepts in Advanced Database System	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	**3**	**0**	**0**	**3**
Pre-Requisite	DBMS	**Co-requisite**	None				
Course Objectives	• To enhance students' knowledge of advanced SQL queries and query optimization techniques. • To understand distributed databases, their architecture, query processing, and recovery mechanisms. • To explore database tuning techniques, performance optimization, and benchmarking strategies. • To gain knowledge of database security, access control, and encryption techniques. • To introduce emerging database technologies such as temporal, spatial, multimedia, and data mining databases.						
Course Outcomes							
CO1	Apply query processing and optimization techniques for efficient database operations.						
CO2	Analyze object-oriented databases, database tuning, and performance benchmarking.						
CO3	Design and manage distributed databases, including concurrency control and recovery mechanisms.						
CO4	Implement database security techniques, encryption, and access control mechanisms.						
CO5	Explore and apply concepts of advanced databases such as temporal, spatial, multimedia, and data mining databases.						

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Query Processing and Optimization**	Clustering & Indexing Techniques, Query Processing Steps and Cost Estimation, Algorithms for Selection, Join, and Projection Operations, Query Optimization: Heuristic Optimization, Cost-Based Optimization, Query Evaluation Plans Pipelined Query Processing, System Catalog in RDBMS	6	1
2	**Object-Oriented and Extended Relational Databases**	Database Tuning: Workloads, Tuning Decisions, and DBMS Benchmarks, Multiple Attribute Search Keys and Optimization Strategies, Object-Oriented Database Systems (OODBMS): Requirements, Properties, and Benefits, Structured Types, Object Identity, Containment, Class Hierarchy, Logic-Based Data Model and Nested Relational Model	7	2
3	**Distributed Databases**	Architecture, Data Fragmentation, Replication, Query Processing, Semi-Join, Parallel Joins, Concurrency Control, Recovery, Deadlock Handling, Commit Protocols	6	3
4	**Database Security and Privacy**	Database Security Threats and Challenges Access Control Mechanisms: Role-Based Access Control (RBAC), Discretionary and Mandatory Access Control (DAC & MAC)SQL Security: Grant & Revoke, Views, Integrity Constraints Data Encryption Techniques in Databases (AES, RSA, Hashing), Statistical Database Security and Anonymization Techniques Role of Database Administrator (DBA) in Security Management	7	4
5	**Advanced and Emerging Databases**	Temporal & Spatial Databases (Time-series Data, Spatial Indexing, GIS Systems), Multimedia Databases (Audio, Video, Image Processing), Data Mining & Knowledge Discovery (Clustering, Association Rules, Decision Trees), Active & Deductive Databases, NoSQL Databases (MongoDB, Cassandra, Hadoop, CAP Theorem, BASE vs. ACID Models)	7	5

Reference Books:

1-Majumdar&Bhattacharya,"DatabaseManagementSystem",TMH.

2-Korth,Silberchatz,Sudarshan,"DatabaseConcepts",AddisonWesley

3-Elmastri,Navathe,"FundamentalsofDatabaseSystems",AddisonWesley

4-DateC.J.,"AnIntroductiontoDatabaseSystem",AddisonWesley.

Program Articulation Matrix (PAM)

PO-PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	3	2	2	3		2	2	3	3	3
CO2	3	3	3	3	3	2	2	3		1	2	3	3	3
CO3	3	3	3	3	2	2	2	2		2	2	3	1	3
CO4	3	3	2	3	3	2	2	2		2	2	3	3	1
CO5	3	2	3	3	2	2	2	3		1	2	1	3	3

1- LowCorrelation;2-ModerateCorrelation;3-SubstantialCorrelation

INTEGRAL UNIVERSITY, LUCKNOW

Effective from Session: 2025-27 (NEP)							
Course Code	**CS342**	**Title of the Course**	**Data Compression**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**V**	**3**	**0**	**0**	**3**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	• To introduce the fundamental concepts of data compression, including lossless and lossy techniques, performance measures, and coding models. • To impart knowledge of Huffman coding, adaptive Huffman coding, and related algorithms for efficient text and audio compression. • To enable students to apply arithmetic coding and dictionary-based techniques (LZ77, LZ78) for image and modem data compression. • To provide understanding of prediction with partial match algorithms, transform-based methods, and advanced compression standards such as JPEG-LS and JBIG. • To develop skills in quantization techniques, including scalar and vector quantization, and structured vector representations for dynamic models.						

Course Outcomes	
CO1	Recall and explain the fundamental concepts of compression techniques (lossless and lossy), performance measures, modeling approaches, and coding principles including uniquely decodable and prefix codes.
CO2	Apply and solve problems using Huffman coding, adaptive Huffman coding, Golomb, Rice, and Tunstall codes, and evaluate their applications in text and audio compression.
CO3	Implement and analyze arithmetic coding and dictionary-based techniques (LZ77, LZ78), and assess their applications in image compression standards such as GIF and JBIG.
CO4	Apply and evaluate prediction with partial match algorithms, transform-based methods (Burrows-Wheeler, Move-to-Front), and advanced compression standards (JPEG-LS, CALIC, facsimile encoding, dynamic Markov compression).
CO5	Design and represent dynamic models using scalar and vector quantization techniques, including Linde-Buzo-Gray algorithm, tree-structured and structured vector quantizers, to develop efficient compression schemes.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Compression Techniques: Loss Less Compression, Lossy Compression, Measures of Performance, Modeling and Coding. Mathematical Preliminaries for Lossless Compression: A Brief Introduction to Information Theory: - Models: Physical Models, Probability Models, Markov Models, Composite Source Model, Coding:-Uniquely Decodable Codes, PrefixCodes	7	1
2	**Huffman Coding**	The Huffman Coding Algorithm: Minimum Variance Huffman Codes, Adaptive Huffman Coding: Update procedure, Encoding procedure, decoding procedure. Golomb Codes, Rice Codes, Tunstall codes. Application of Huffman Coding. Text compression, Audio Compression	6	2
3	**Arthmatic Coding**	Coding a Sequence, Generating a Binary Code, Comparison of Binary and Huffman Coding, Applications: Bi-Level Image Compression-JBIG and JBIG2 Standards. Dictionary Techniques: Introduction, Static Dictionary: - Diagram Coding, Adaptive Dictionary: The LZ77 Approach, The LZ78 Approach Applications. Image Compression: The Graphics Interchange Format (GIF), Compression over Modem	7	3
4	**Prediction with Partial Match**	The Basic Algorithm, The ESCAPE SYMBOL, Length of Context, The Exclusion Principle, The Burrows-Wheeler Transform, Move-to- Front Coding, CALIC, JPEG-LS, Multi- resolution Approaches, Facsimile Encoding, Dynamic Markov Compression	7	4
5	**Quantization**	Introduction of Scalar and Vector Quantization, Advantages of Vector Quantization Over Scalar Quantization, The Linde-Buzo-Gray Algorithm, Tree Structured Vector Quantizes, Structured Vector Quantizes.	6	5

Reference Books:

1.Introduction to Data Compression, Second Edition, Khalid Sayood, The Morgan Kaufmann Series

2. Data Compression: The Complete Reference 4th Edition by David Salomon, Springer

3. Text Compression1st Edition by Timothy C. Bell Prentice Hall

4. Elements of Data Compression, Drozdek, Cengage Learning

e-Learning Source:

https://nptel.ac.in/courses/106105166

Program Articulation Matrix														
PO- PSO / **CO**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	2							3	2	2
CO2	2	2	2	2	2							2	2	1
CO3	2	2	1	1	2							3	2	1
CO4	3	2	1	2	1	2	1					3	2	1
CO5	2	2	3	2	2	1	1	1				3	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective Session: 2026-27 (NEP)							
Course Code	**CS412**	**Title of the Course**	**Cryptography and Network Security**	**L**	**T**	**P**	**C**
Year	**III**	**Semester**	**VI**	**4**	**0**	**0**	**4**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	Understand the theory and applications of cryptography and network security. The aim of this course is to introduce the student to the areas of cryptography and cryptanalysis. This course develops a basic understanding of the algorithms used to protect users online and to understand some of the design choices behind these algorithms. Aim is to develop a workable knowledge of the mathematics used in cryptology in this course. Reveal different types of cipher generation method to solve engineering and other problems.						

Course Outcomes	
CO1	To understand both classical and modern encryption techniques, as well as the ability to analyze cryptographic systems and evaluate their effectiveness in securing data.
CO2	Apply your knowledge of block cipher modes to achieve secure communication and analyze the role of random numbers in cryptographic algorithms.
CO3	Apply, analyze and compare various public key cryptography techniques
CO4	To design, implement, and analyze secure authentication and digital signature systems in real-world scenarios.
CO5	Able to analyze appropriate secure communication protocols based on security requirements and implement basic network security measures using firewalls.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to OSI Security Architecture:**	Security Attacks, Services and Mechanisms, Introduction to Cryptology. Conventional Encryption: Conventional Encryption Model, Classical Encryption Techniques– Substitution Ciphers: Caesar Cipher, Monoalphabetic Cipher, Playfair Cipher, Hill Cipher, Polyalphabetic Cipher, One-Time Pad; Transpositions Ciphers: Rail Fence Technique; Rotor Machines, Cryptanalysis, Steganography. Modern Block Ciphers- Block Ciphers Principles: Stream & Block Ciphers, Fiestal Cipher, Shannon's Theory of Confusion and Diffusion, S-DES, Data Encryption Standards (DES): DES Encryption and Decryption, Strength of DES.	**8**	**1**
2	**Block Cipher Modes of Operation:**	ECB, CBC, CFB, OFB, CTR, Triple DES: Double DES, TDES with Two Keys, TDES with Three Keys. Symmetric Key Distribution using KDC, Random Number Generation: Use of Random Numbers, Pseudo Random Number Generators, Cryptographically Generated Random Numbers, Blum BlumShub Generator. Introduction to Graph, Ring and Field, Prime and Relative Prime Numbers, Modular Arithmetic, Fermat's & Euler's Theorem, Primality Testing, Euclid's Algorithm.	**8**	**2**
3	**Principles of Public Key Cryptosystems:**	Introduction, Application & Requirement; RSA Algorithm: Computational Aspects, Security of RSA; Diffie-Heilman Key Exchange Algorithm, Introductory Idea of Elliptic Curve Cryptography. Message Authentication & Hash Functions: Authentication Requirements, Authentication Functions, Message Authentication Codes (MAC), Hash Functions: Requirement for a Hash Function, Simple Hash Functions, Security of Hash Function & MAC, MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA-1).	**8**	**3**
4	**Digital Signatures:**	Requirements, Direct & Arbitrated Digital Signature, Protocols: Mutual & One way Authentication; Digital Signature Standard (DSS): DSS Approach, Digital Signature Algorithm. Authentication Applications: Kerberos Version 4 & Difference between Kerberos v4 & v5, Kerberos Realms; X.509 Authentication Service: Authentication Procedures, Directory Authentication Service; Electronic Mail Security – Pretty Good Privacy (PGP): Operational Description, Cryptographic Keys, Key Rings, Public Key Management.	**8**	**4**
5	**IP Security:**	Architecture, Authentication Header, Encapsulating Security Payloads, Combining Security Associations, Key Management; Web Security: Secure Socket Layer & Transport Layer Security, Secure Electronic Transaction (SET). System Security: Intruders, Viruses and Related Threats: Malicious Programs, The Nature of Viruses, Types of Viruses, Macro Viruses, Email Viruses; Firewall: Firewall Design Principles, Trusted Systems.	**8**	**5**

Reference Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice" Prentice Hall, New Jersey.
2. Johannes. A. Buchmann, "Introduction to cryptography", Springer Verlag. Bruce Schiener, "Applied Cryptography".

e-Learning Source:

https://nptel.ac.in/courses/106105031

Program Articulation Matrix (PAM)														
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1		2						3	3	2
CO2	3	3	3	3								3	3	2
CO3	3	3	1	2								3		3
CO4	3	3	3	3		1	2	2	2		3	3	3	3
CO5	3	3	3	3	3			1			3	3	3	3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2016-17							
Course Code	**CS-412**	**Title of the Course**	**Cryptography and Network Security**	**L**	**T**	**P**	**C**
Year	**IV**	**Semester**	**VII**	**3**	**1**	**0**	**4**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	Understand the theory and applications of cryptography and network security. The aim of this course is to introduce the student to the areas of cryptography and cryptanalysis. This course develops a basic understanding of the algorithms used to protect users online and to understand some of the design choices behind these algorithms. Aim is to develop a workable knowledge of the mathematics used in cryptology in this course. Reveal different types of cipher generation method to solve engineering and other problems.						

Course Outcomes	
CO1	To understand both classical and modern encryption techniques, as well as the ability to analyze cryptographic systems and evaluate their effectiveness in securing data.
CO2	Apply your knowledge of block cipher modes to achieve secure communication and analyze the role of random numbers in cryptographic algorithms.
CO3	Apply, analyze and compare various public key cryptography techniques
CO4	To design, implement, and analyze secure authentication and digital signature systems in real-world scenarios.
CO5	Able to analyze appropriate secure communication protocols based on security requirements and implement basic network security measures using firewalls.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to OSI Security Architecture:**	Security Attacks, Services and Mechanisms, Introduction to Cryptology. Conventional Encryption: Conventional Encryption Model, Classical Encryption Techniques – Substitution Ciphers: Caesar Cipher, Monoalphabetic Cipher, Playfair Cipher, Hill Cipher, Polyalphabetic Cipher, One-Time Pad; Transpositions Ciphers: Rail Fence Technique; Rotor Machines, Cryptanalysis, Steganography. Modern Block Ciphers- Block Ciphers Principles: Stream & Block Ciphers, Fiestal Cipher, Shannon's Theory of Confusion and Diffusion, S-DES, Data Encryption Standards (DES): DES Encryption and Decryption, Strength of DES.	8	1
2	**Block Cipher Modes of Operation:**	ECB, CBC, CFB, OFB, CTR, Triple DES: Double DES, TDES with Two Keys, TDES with Three Keys. Symmetric Key Distribution using KDC, Random Number Generation: Use of Random Numbers, Pseudo Random Number Generators, Cryptographically Generated Random Numbers, Blum BlumShub Generator. Introduction to Graph, Ring and Field, Prime and Relative Prime Numbers, Modular Arithmetic, Fermat's & Euler's Theorem, Primality Testing, Euclid's Algorithm.	8	2
3	**Principles of Public Key Cryptosystems:**	Introduction, Application & Requirement; RSA Algorithm: Computational Aspects, Security of RSA; Diffie-Heilman Key Exchange Algorithm, Introductory Idea of Elliptic Curve Cryptography. Message Authentication & Hash Functions: Authentication Requirements, Authentication Functions, Message Authentication Codes (MAC), Hash Functions: Requirement for a Hash Function, Simple Hash Functions, Security of Hash Function & MAC, MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA-1).	8	3
4	**Digital Signatures:**	Requirements, Direct & Arbitrated Digital Signature, Protocols: Mutual & One way Authentication; Digital Signature Standard (DSS): DSS Approach, Digital Signature Algorithm. Authentication Applications: Kerberos Version 4 & Difference between Kerberos v4 & v5, Kerberos Realms; X.509 Authentication Service: Authentication Procedures, Directory Authentication Service; Electronic Mail Security – Pretty Good Privacy (PGP): Operational Description, Cryptographic Keys, Key Rings, Public Key Management.	8	4
5	**IP Security:**	Architecture, Authentication Header, Encapsulating Security Payloads, Combining Security Associations, Key Management; Web Security: Secure Socket Layer & Transport Layer Security, Secure Electronic Transaction (SET). System Security: Intruders, Viruses and Related Threats: Malicious Programs, The Nature of Viruses, Types of Viruses, Macro Viruses, Email Viruses; Firewall: Firewall Design Principles, Trusted Systems.	8	5

Reference Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice" Prentice Hall, New Jersey.

2. Johannes. A. Buchmann, "Introduction to cryptography", Springer Verlag. Bruce Schiener, "Applied Cryptography".

e-Learning Source:

https://nptel.ac.in/courses/106105031

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	1		2							3	3		2
CO2	3	3	3	3									3	3		2
CO3	3	3	1	2									3		3	2
CO4	3	3	3	3		1	1	2	2	2		3	3	3	3	3
CO5	3	3	3	3	3				1			3	3	3	3	2

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective Session: 2026-27 (NEP)							
Course Code	CS292	**Title of the Course**	Theory of Computation	**L**	**T**	**P**	**C**
Year	III	**Semester**	VI	4	0	0	4
Pre-Requisite	Discrete Mathematics	**Co-requisite**	None				
Course Objectives	The primary objective of this course is to introduce students to the foundations of computability theory. Other objectives include the application of mathematical techniques and logical reasoning to important problems, and to develop a strong background in reasoning about finite state automata and formal languages.						

Course Outcomes	
CO1	Demonstrate computational mathematical models for problem solving and describe how they relate to formal languages.
CO2	Understand and analyze the relationship among language classes and Grammars with the help of Chomsky Hierarchy.
CO3	Identify and apply rigorous formal mathematical models for proving different properties of Grammar, languages and Automata.
CO4	Recall mathematical foundations and algorithmic principles, understand their role in system design, apply to models, analyze effectiveness, and evaluate its real-world utility.
CO5	Examine the applicability of theoretical concepts to practical engineering problems, such as compiler design.

THEORY

S. No.	Title of the Units	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to Automata**	Finite state machine, definitions, Finite automaton model, acceptance of strings and languages Deterministic Finite Automata (DFA), Nondeterministic Finite Automata (NFA), NFA with epsilon transition, Language of NFA, Equivalence of NFA and DFA, Minimization of Finite Automata, FA with output: Moore and Mealy machine, Equivalence of Moore and Mealy Machine, Applications and Limitation of FA	9	1
2	**Regular Expression & Languages**	Chomsky Hierarchy, Regular Grammars, Unrestricted Grammars, Context Sensitive Language, Regular expression (RE); Definition, Operators of regular expression and their precedence, Algebraic laws for Regular expressions, Kleen's Theorem, Regular expression to FA, DFA to Regular expression, Arden Theorem, Non-Regular Languages, Pumping Lemma for regular Languages. Application of Pumping Lemma, Closure properties of Regular Languages, Decision properties of Regular Languages	8	2
3	**Context free Grammar and Context Free Languages**	Context free grammar (CFG) and Context Free Languages (CFL): Definition, Examples, Derivation, Derivation trees, Ambiguity in Grammar, Ambiguous to Unambiguous CFG, Useless symbols, Simplification of CFGs, Normal forms for CFGs: CNF and GNF, Closure properties of CFLs, Decision Properties of CFLs: Emptiness, Finiteness and Membership, Pumping lemma for CFLs.	9	3
4	**Push Down Automata (PDA):**	Push Down Automata (PDA): Description and definition, Instantaneous Description, Language of PDA, Acceptance by Final state, Acceptance by empty stack, Deterministic PDA, Equivalence of PDA and CFG, CFG to PDA and PDA to CFG, Two stacks PDA, Non-Deterministic Push Down Automata.	7	4
5	**Turing Machines (TM):**	Turing machines (TM): Basic model, definition and representation, Instantaneous Description, Language acceptance by TM, Variants of Turing Machine, TM as Computer of Integer functions, Universal TM, Church's Thesis, Recursive and Recursively Enumerable languages, Halting problem, Introduction to Undecidability, Undecidable problems about TMs. Post correspondence problem (PCP), Modified PCP, Introduction to recursive function theory	7	5

Reference Books:

1. *Hopcroft and Ullman, "Introduction to Automata Theory Languages and Computation", Addison Wesley.*
2. *Mishra & Chandrasekhar, "Theory of Computer Sciences", PHI.*
3. *Peter Linz, "An Introduction to Formal Languages and Automata", Jones & Bartlett Learning. Recommended Prerequisite – CS206Co-requisite - None*

e-Learning Resources:

https://nptel.ac.in/courses/106105196

Course Articulation Matrix: (Mapping of COs with POs and PSOs)														
PO-PSO /CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2						1	1	1		3
CO2	3	2	3	2	2	1						2		3
CO3	3	3	3	2		2						2		3
CO4	3	2	2	2	3	3		2		1	1	2		
CO5	3	2	1	1		2				2			1	2

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	CS395	**Title of the Course**	Predictive Analytics	**L**	**T**	**P**	**C**
Year	III	**Semester**	V	**4**	**0**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	● To provide an overview of an exciting field of Predictive Analytics. ● To introduce the tools required For Predictive Analytics. ● Review and explore data to look at data distributions and to identify data problems, including missing values. ● To enable students to have skills that will help them to solve complex real-world problems for decision support. ● To study, understand and implement each unit according to National Education Policy and Bloom's Taxonomy.						

Course Outcomes	
CO1	Define Predictive Analytics and recall its key concepts as an emerging field.
CO2	Explain the purpose and use of tools required for Predictive Analytics.
CO3	Apply data exploration techniques to review datasets, examine distributions, and detect issues such as missing values.
CO4	Analyze complex real-world problems using acquired skills to support effective decision-making.
CO5	Evaluate and apply IBM Watson Studio and its tools to develop and assess end-to-end machine learning solutions.

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**ANALYTICS OVERVIEW**	Definition of business Analytics with real time examples, role of analytics in decision-making, data-driven business strategies, How Predictive analytics: Transforming data into future insights, case studies on business forecasting, Analytics trends: Past, Present & Future, Towards a Predictive enterprise.	8	1
2	**IBM SPSS MODELER & DATA MINING**	Introduction to data mining, real-world applications Strategy for data mining: CRISP-DM, Identify nodes and streams, The framework of a Data – mining project, Brief the unit of analysis, types of dialog box, case studies in business and healthcare. Concepts of Unit of analysis (Distinct, Aggregate, SetToFlag), Integrate data, CLEM Expression, Role of Relationship between two fields, Identifying the modeling objective.	8	2
3	**IBM SPSS MODELER & DATA MINING**	Concepts of Unit of analysis (Distinct, Aggregate, SetToFlag), Integrate data, CLEM Expression, Role of Relationship between two fields, Identifying the modeling objective.	8	3
4	**ADVANCED DATA PREPARATION WITH IBM SPSS MODELER**	Functions to enrich data, Method to transform data, Cross-record functions, Sampling, Partitioning and sampling data, Improving Efficiency.	8	4
5	**PREDICTIVE ANALYTICS WITH IBM WATSON STUDIO**	IBM Watson Studio, Watson studio Components, Data preparation, Watson Machine learning, Data Refinery, Watson Studio Neural Network Modeler, IBM Watson Studio jobs, Use case with AutoAI.	8	5

Reference Books:

1. IBM Courseware
2. Predictive Analytics Mesmerizing & fascinating by ERIC SIEGEL
3. IBM SPSS Predictive Analytics: Optimizing Decisions at the Point of Impact
4. An Introduction to Secondary Data Analysis with IBM SPSS Statistics

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	2		2	2		1	1	1	1	2		2
CO2	2	3		1	3	3	1	1		2		2		3
CO3	2	1	3	3	1	3	1	2	3	3	3	3	3	1
CO4	2	2	3	3	1	3		2	1	3	3	3	3	3
CO5	2	2	3	3	2	3	2	3	2	3	3	3	3	3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective Session: 2026-27 **(NEP)**							
Course Code	CS338	**Title of the Course**	Mobile App Development Lab	**L**	**T**	**P**	**C**
Year	III	**Semester**	V	0	0	2	1
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The Mobile App Development Lab aims to empower students with the practical skills and knowledge required to conceive, develop, and deploy innovative mobile applications that address real-world challenges and user needs.						

Course Outcomes	
CO1	Understand the industry-standard development environments, integrated development environments (IDEs), and software development kits (SDKs) for mobile platforms.
CO2	Apprehend the fundamental concepts of mobile app development, using user-interface design, data management, and application lifecycle.
CO3	Implement essential concepts and features in mobile apps development
CO4	Debug and troubleshoot common issues in mobile app development, employing debugging tools and techniques effectively.
CO5	Build and Develop Mobile Apps using the fundamental concepts of mobile app development approaches and stratagies.

S. No.	**List of Experiments**	**Contact Hrs.**	**Mapped CO**
1	Develop an application that uses GUI components, Font, and Colors.	2	1
2	Develop an application that uses Layout Managers and event listeners.	2	1
3	Write an application that draws basic graphical primitives on the screen.	2	2
4	Develop an application that makes use of databases.	2	2
5	Develop an application that makes use of Notification Manager.	2	3
6	Implement an application that uses multi-threading.	2	3
7	Develop a native application that uses GPS location information.	2	4
8	Develop a mobile application to send an email.	2	4
9	Implement an application that writes data to the SD card.	2	5
10	Develop a Mobile application for simple needs (Mini Project).	2	5

e-Learning Source:

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO- PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	3	1	3		1	1		1	1	1	3	3
CO2	2	2	3	3	1		2	1		1	2	2	2	1
CO3	1	1	1	2	3		2	2		2	1		3	2
CO4	2	2	1	2	2		1	3		3		2	1	1
CO5	1	2	1	3	1	3		2	3	2	1	1	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27 (NEP)							
Course Code	CS391	**Title of the Course**	Hadoop	**L**	**T**	**P**	**C**
Year	III	**Semester**	V	4	0	2	5
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	1. To provide an overview of an exciting field of big data analytics and Hadoop. 2. Develop an understanding of the complete open-source Hadoop ecosystem and its near-term future direction. 3.To introduce the tools required to manage and analyze big data like Hadoop, NoSQL MapReduce 4. To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability. 5.To enable students to have skills that will help them to solve complex real-world problems in decision support						

Course Outcomes	
CO1	Understand the fundamental concepts of Big Data, Hadoop ecosystem, types of data, and the evolution of Hadoop architecture along with its role in modern data processing.
CO2	Demonstrate the architecture and application of HDFS and its components such as NameNode, Secondary NameNode, and Zookeeper.
CO3	Apply Hadoop commands and APIs to manage distributed storage and processing, including implementing file operations in HDFS and executing MapReduce programs.
CO4	Implement big data processing solutions using MapReduce and related ecosystem tools such as Hive, Pig, Flume, Hbase and Ambari for handling large-scale datasets.
CO5	Analyze and compare big data tools and technologies such as Hadoop, RDBMS, Hive, and Pig, and evaluate their suitability for different data storage and processing scenarios.

THEORY

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Big Data**	Develop an understanding of the complete open-source Hadoop ecosystem and its near-term future directions, compare and evaluate the major Hadoop distributions and their ecosystem components both their strengths and their limitations, and hands-on experience with key components of various big data ecosystem components and roles in building a complete big data, Future of Big Data. Knowledge of data, How to use Big insight.	8	1
2	**Hadoop**	Why Hadoop? What is Hadoop? Hadoop vs RDBMS, Hadoop vs Big Data, Types of Data, Brief history of Hadoop, Problems with traditional large-scale systems, Requirements for a new approach, Anatomy of a Hadoop cluster. , the overall architecture of Ambari and Ambari' relation to other services and components of a Hadoop cluster, the functions of the main components of Ambari, initiating start and stop services from Ambari Web Console.	8	1,5
3	**HDFS**	Concepts & Architecture, Data Flow (File Read, File Write), Fault Tolerance, Shell Commands, Java Base API, Data Flow Archives, Coherency, Data Integrity, Role of Secondary Name Node, Zookeeper.	8	2,3
4	**MapReduce**	Theory, Data Flow (Map – Shuffle - Reduce), Map Red vs MapReduce APIs, Programming Mapper, Reducer, Combiner, Partitioner, Implementation of Mahout, R, Sqoop, Yarn, what is flume Flume, the architecture of Flume, Flume Modes. Introduction to Spark and Kafka.	8	3,4
5	**Hive and Pig**	List the characteristics of representative data file formats including flat/text files CSV XML JSON and YAML, Architecture, Installation, Configuration, Hive vs RDBMS, Tables, DDL & DML, Partitioning & Bucketing, Hive Web Interface, Why Pig, Use case of Pig, Pig Components, Data Model, Pig Latin.	8	4,5

PRACTICAL

S. No.	List of Experiments	Contact Hrs.	Mapped CO
1	Perform setting up and installing Hadoop in its three operating modes: Standalone, Pseudo Distributed, Fully Distributed from scratch.	2	1
2	Install and Setup Hadoop cluster on Ambari console using Virtual box.	2	1
3	Implement the following file management tasks in Hadoop: • Adding files and directories • Retrieving files • Deleting files • Hint: A typical Hadoop workflow creates data files (such as log files) elsewhere and copies them into HDFS using one of the above command line utilities.	2	3
4	Install and Run Hive then use Hive to create, load, alter, and drop databases, tables.	2	4
5	Implement Hive Partitioning with data set.	2	4
6	Implement Hive bucketing with data set.	2	4
7	Run a basic Word Count Map Reduce program to understand Map Reduce paradigm with data set.	2	4

8	Implement Matrix Multiplication with Hadoop MapReduce.	2	4
9	Implement Hbase commands with data set.	2	4
10	Install and Run Pig then write Pig Latin scripts to sort, group, join and filter your data.	2	4
11	Explore Zookeeper.	2	2

Reference Books:

1. Kumar, Nitin. Big Data Using Hadoop and Hive, Berlin, Boston: Mercury Learning and Information, 2021. https://doi.org/10.1515/9781683926443
2. T. Deshpande, Hadoop Real-World Solutions Cookbook (Packt Publishing, 2016) 290 p
3. Machine Learning for Big Data: Hands-On for Developers and Technical Professionals" by Jason Bell. Bell, 2nd ed. Wiley, 2020. Web. 15 Oct. 2022.
4. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data" by EMC Education Services

e-Learning Source:

https://www.linkedin.com/learning/topics/hadoop-2

https://www.coursera.org/learn/data-engineering-pipelines-etl-hadoop

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		1	2						1	3	1	1
CO2	3	2	1		2						1	3	2	1
CO3	3			1	3						1	3	2	2
CO4	3	1	2	2	2						1	3	3	2
CO5	3	3		1	2						1	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation