DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF LUCKNOW

M.Sc. Computer Science (PG 2 Year) Programme

YEAR 2–SEMESTER III

CORE COURSE 11
Course code: MSCTCC301
Course Title: Data Warehousing and Data Mining

Credit: 4

Course Objectives:

- ✓ To understand the principles of Data warehousing and Data Mining.
- ✓ To understand the Architecture of a Data Mining system.
- ✓ To perform classification, association, and prediction of data.
- ✓ To describe different data mining tasks and apply algorithms suitable for the given task.
- ✓ To use programming tools for solving data mining tasks.

UNIT	TOPICS
Unit I	Data Warehousing- Introduction and Design: Overview and Concepts: Data Warehousing Components, Building a Data Warehouse, Data Warehouse Architecture, Infrastructure and Metadata. Data Design and Data Representation: Principles of Dimensional Modelling, Data Extraction, Transformation and Loading, Data Quality, Online Analy tical Processing (OLAP)–OLAP and Multidimensional Data Analy sis.
Unit II	Data Mining Pre-processing: Steps in Data mining process, Data Mining Functionalities, Architecture of a Ty pical Data Mining Sy stems, Classification of Data Mining Systems, Knowledge Discovery in Databases (KDD), KDD Process, Data Preprocessing, Data Cleaning, Data Transformation, Data Compression and Dimension Reduction, Principal Component Analysis, Binning Methods.
Unit III	Association Rule Mining, Classification and Prediction: Efficient and Scalable Frequent Itemset Mining Methods, Various Kinds of Association Rules, Market Basket Analysis, Apriori Algorithm, Tree Based Algorithms, Classification by Decision Tree Introduction, Bayesian Classification, Rule Based Classification, Classification by Back propagation, Support Vector Machines, Lazy Learners, Prediction Techniques, Regression Models
Unit IV	Clustering. Partitioned Algorithms, Hierarchical Algorithms, Density Based, Algorithms, Grid Based Algorithms, Web Content Mining, Web Structure Mining, Web Usage Mining, Spatial Mining, Multimedia Data Mining, Text Mining.

REFERENCE BOOKS:

1.	"Data Mining Tools and Techniques", J. Han and M. Kamber, Morgan Kaufmann Publishers, 2001
2.	"Data Mining Introductory and Advanced Topics", M.H. Dunham, Pearson Education, 2006
3.	"Introduction to Data Mining", Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson Education, 2006
4.	"Data warehousing- concepts, Techniques, Products and Applications", Prabhu, Prentice Hall of India, 2008

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YEAR 2–SEMESTER III

CORE COURSE 12
Course code: MSCTCC302
Course Title: Compiler Design

Credit: 4

Course Objectives:

- ✓ To understand the theoretical foundations and concepts of compiler design
- ✓ To acquire knowledge about the different compilation phases
- ✓ To learn how to design and implement lexical analysers and parsers
- ✓ To gain hands-on experience in building semantic analysers

UNIT	TOPICS
Unit I	Lexical Analysis, Review of regular languages and finite automata, design of a lexical analyser generator, context-free grammars. Syntax Analysis: Review of context free grammar, top-down parsing: recursive descent and predictive parsing, LL(k) parsing; bottom-up parsing: LR parsing, handling ambiguous in bottom-up parsers.
Unit II	Syntax directed translation, Top down and bottom-up approaches, data types, mixed mode expression; subscripted variables, sequencing statement, subroutines and functions: parameters calling, subroutines with side effects. Code Optimization: Data flow analysis, Common subexpression elimination, Constant folding and propagation, Loop optimization techniques
Unit III	Code generation, Machine code generation, machine dependent and machine independent optimization techniques. Runtime Environments: Activation records and stack management. Heap memory management, Call and return mechanisms, Exception handling Lexical and Syntax Error Handling: Error recovery strategies Error reporting and handling
Unit IV	Introduction to Compiler Tools, Techniques and Advanced Topics in Compiler Design: Lexical and syntax analyser generators, Code generation frameworks (e.g., LLVM), Debugging and testing compilers, Just-in-time (JIT) compilation, Parallel and concurrent programming support, Compiler optimization frameworks, Domain-specific language (DSL) compilation

REFERENCE BOOKS:

1.	Alfred V. Aho, Ravi Sethi, D. Jeffrey Ulman, Monica S. Lam, Compilers-Principles, Techniques and Tools, Pearson Education India, 2013
2.	"Compiler Design", K Muneeswaran, Oxford University Press, 2012
3.	"Modern Compiler Design", Dick Grune, Kees van Reeuwijk, Henri E. Bal, Ceriel J.H. Jacobs, Koen Langendoen, Springer Science & Business Media, 2016
4.	"Modern Compiler Implementation in C" by Andrew W. Appel, Cambridge University Press, 2020

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YEAR 2–SEMESTER III

CORE COURSE 13

Course code: MSCTCC303

Course Title: Signal And Image Processing

Credit: 4

Course Objectives:

- ✓ To understand the applications of digital image processing.
- ✓ To gain proficiency in image processing techniques.
- ✓ To implant skills in edge detection and image segmentation.
- ✓ To utilize morphological operations for image enhancement, and noise reduction.

UNIT	TOPICS
Unit I	Fundamentals of Digital Signals Processing: Periodic signals, Spectral decomposition, Signals, Reading and writing Waves, Spectrums, Wave objects, Signal objects ,Noise: Uncorrelated noise, Integrated spectrum, Brownian noise, Pink Noise, Gaussian noise; Autocorrelation: Correlation, Serial correlation, Autocorrelation, Autocorrelation of periodic signals, Correlation as a dot product Frequency domain Operations: Representing Image as Signals, Sampling and Fourier Transforms, Discrete Fourier Transform, Convolution and Frequency Domain Filtering, Smoothing using lowpass filters, Sharpening using high-pass filters. Fast Fourier Transforms.
Unit II	Image Processing fundamentals and Pixel Transformation: Definition, Application of Image Processing, Image Processing Pipeline, Tools and Libraries for Image Processing, Image types and files formats. Intensity Transformations- Log Transform, Power-law Transform, Contrast Stretching, Thresholding Histogram Processing- Histogram Equalization and Histogram Matching; Linear and Non-linear smoothing of Images, Sharpening of Images Image Derivative: Derivatives and gradients, Laplacian, the effect of noise on gradient computation
Unit III	Structural and Morphological Operations Edge Detection: Sobel, Canny Prewitt, Robert edge detection techniques, LoG and DoG filters, Image Pyramids: Gaussian Pyramid, Laplacian Pyramid Morphological Image Processing: Erosion, Dilation, Opening and closing, Hit-or-Miss Transformation, Skeletonizing, Computing the convex hull, removing small objects, White and black tophats, Extracting the boundary, Grayscale operation
Unit IV	Advanced Image Processing Operations Extracting Image Features and Descriptors: Feature detector versus descriptors, Boundary Processing and feature descriptor, Principal Components, Harris Corner Detector, Blob detector, Histogram of Oriented Gradients, Scale-invariant feature transforms, Haar-like features Image Segmentation: Hough Transform for detecting lines and circles, Thresholding and Otsu's segmentation, Edge-based/region based segmentation Region growing,

	Region splitting and Merging, Watershed algorithm, Active Contours, morphological snakes, and GrabCut algorithms
REFERENCE BOOKS:	
1.	"Digital Image Processing", Rafael Gonzalez & Richard Woods, Pearson, 2018
2.	"Think DSP: Digital Signal Processing in Python" Allen Downey, O'Reilly Media 2016.
3.	"Understanding Digital Image Processing", Vipin Tyagi, CRC Press, 2018
4.	"Hands-On Image Processing with Python", Sandipan Dey, Packt Publishing, 2018.

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YEAR 2–SEMESTER III

ELECTIVE COURSE 14a
Course code: MSCTEC304A
Course Title: Internet of things

Credit: 4

Course Objectives:

- ✓ To understand the basic terminologies of IoT.
- ✓ To acquire knowledge about the real time application of IoT.
- ✓ To introduce the Python Scripting Language for IoT devices.
- ✓ To understand the utility of IoT based webservices.

UNIT	TOPICS
Unit I	Introduction IoT, IoT Building Blocks-Hardware and Software: The basic IoT building blocks, smart thing components and capabilities, basics of Packet Tracer with reference to IoT, Cloud, and analytics Sensing Principles and Wireless Sensor Network: WSN architecture and types, layer-level functionality of WSN protocol stack.
Unit II	IoT architecture domains, IoT gateway architecture, IoT gateway functionalities, edge computing, IoT Cloud and Fog Computing: Components of IoT Cloud architecture, usage of application domains of IoT Cloud platforms, layered architecture of Fog computing, distinguish Fog computing from other related terms IoT Applications: Main applications of IoT, Implementation details of various IoT application domains
Unit III	IoT Security, Security constraints in IoT systems, security requirements of IoT systems, IoT attacks, security threats at each layer of IoT architecture, design secure IoT system for specific application Social IoT: Nature of social relationships among IoT Devices, functionality of different components of social IoT architecture, social aspects of smart devices in IoT applications.
Unit IV	Sensors, Light sensor, temperature sensor with thermistor, voltage sensor, ADC and DAC, Temperature and Humidity Sensor DHT11, Motion Detection Sensors, Wireless Bluetooth Sensors, Level Sensors, USB Sensors, Embedded Sensors, Distance Measurement with ultrasound sensor IoT Physical Servers and Cloud Offerings– Introduction to Cloud Storage models and communication APIs Web Server – Web server for IoT, Cloud for IoT.

REFERENCE BOOKS:

1.	"Internet of Things - A Hands-on Approach", Arshdeep Banga and Vijay Madisetti, Universities Press, 2015
2.	"Introduction to Embedded Systems – Cyber physical systems Approach" Edward Ashford Lee & Sanjit Arun Kumar Seshia, MIT Press, 2017

3.	"Enabling the Internet of Things Fundamentals, Design and Applications" Muhammad Azhar Iqbal, Sajjad Hussain, Huanlai Xing, Muhammad Ali Imran, Wiley Pub. 2021
4.	"Build your own IoT Platform Develop a Fully Flexible and Scalable Internet of Things Platform in 24 Hours", Anand Tamboli, Apress 2019

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M.Sc. Computer Science (PG 2 Year) Programme

YEAR 2–SEMESTER III

ELECTIVE COURSE 14b
Course code: MCTEC304B
Course Title: Graph Theory

Credit: 4

Course Objectives:

- ✓ To understand the fundamental concept of graph theory.
- ✓ To know the rules of graphs in algorithm design.
- ✓ To know the concepts of graph theory in complexity reduction
- ✓ To implant graph theory concept in real time computing applications.

UNIT	TOPICS
Unit I	Fundamental Concepts of Graphs, Definitions, examples of problems in graph theory, adjacency and incidence matrices, isomorphism, paths, walks, cycles, components, cut-edges, cut-vertices, bipartite graphs, Eulerian graphs, vertex degrees, reconstruction conjecture, extremal problems, degree sequences, directed graphs, de Bruijn cycles, Orientations and tournaments
Unit II	Trees and forests, characterizations of trees, spanning trees, radius and diameter, enumeration of trees, Cayley's formula, Counting spanning trees, deletion-contraction, matrix tree theorem, graceful labelling, minimum spanning trees (Kruskal's algorithm), shortest paths (Dijkstra's algorithm).
Unit III	Matchings, maximal and maximum matchings, M-augmenting paths, Hall's theorem and consequences, Min-max theorems, maximum matchings and vertex covers, independent sets and edge covers, Connectivity, vertex cuts, Edge-connectivity. Connectivity and Paths: Blocks, k-connected graphs, Menger's theorem, line graphs, network flow problems, flows and source/sink cuts, Ford-Fulkerson algorithm, Max-flow min-cut theorem.
Unit IV	Graph Colouring, Vertex colourings, bounds on chromatic numbers, Chromatic numbers of graphs constructed from smaller graphs, chromatic polynomials; properties of the chromatic polynomial, the deletion-contraction recurrence. Planar Graphs: Planar graphs, Euler's formula, Kuratowski's theorem, five and four-color theorems.

REFERENCE BOOKS:

1.	"Introduction to Graph Theory", Douglas B West, Pearson, 2017
2.	"Introduction to Graph Theory", Gary Chartrand and Ping Zhang, Tata McGraw Hill, 2017
3.	"Graph Theory and Its Applications", Jonathan L. Gross and Jay Yellen, Chapman Hall (CRC), 2005

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YEAR 2--SEMESTER III

ELECTIVE COURSE 14c Course code: MSCTEC304C Course Title: Multi-Agent Systems	
Credit: 4	
Course Objectives: ✓ To gain knowledge about the fundamental concepts of intelligent agents. ✓ To understand and implement practical reasoning agents. ✓ To understand the working of reactive agent architectures. ✓ To understand agent communication and machine-based interactions.	
UNIT	TOPICS
Unit I	Intelligent Agents, Environments, Intelligent Agents, Agents and Objects, Agents and Expert Systems, Agents as Intentional Systems, Abstract Architectures for Intelligent Agents, Purely Reactive Agents, Perception, Agents with State, How to Tell an Agent What to Do, Utility Functions, PEAS.
Unit II	Practical Reasoning Agents, Practical Reasoning, Means-Ends Reasoning, Implementing a Practical Reasoning Agent, Commitment to Ends and Means, Procedural Reasoning System. Reactive and Hybrid Agents, Brooks and the Subsumption Architecture, Limitations of Reactive Agents, Hybrid Agents
Unit III	Multiagent Interactions, Utilities and Preferences, Multiagent Encounters, Dominant Strategies and Nash Equilibria, Competitive and Zero-Sum Interactions, The Prisoner's Dilemma. Reaching Agreements, Mechanism Design, Auctions, Negotiation, Task-Oriented Domains, Worth-Oriented Domains, Argumentation
Unit IV	Agent Communication, Speech Acts, Agent Communication Languages, KIF, KQML, The FIPA Agent Communication Languages, Ontologies for Agent Communication, Coordination Languages. Cooperative Distributed Problem Solving, Coherence and Coordination, Task Sharing and Result Sharing, Task Sharing in the Contract Net, Result Sharing, Handling Inconsistency, Coordination, Multiagent Planning and Synchronisation

REFERENCE BOOKS:

1.	"Michael Wooldridge, An Introduction to Multiagent Systems", John Wiley & Sons, 2009.
2.	"Multiagent Systems--A Modern Approach to Distributed Artificial Intelligence", G. Weiss, MIT Press, Cambridge, 2013.
3.	"Artificial Intelligence: A Modern Approach", S. Russell and P. Norvig, Pearson Education, 2015.

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4.	"Programming Multi-Agent Systems in AgentSpeak using Jason- Wiley Series in Agent Technology,", Rafael H. Bordini, Jomi Fred Hübner, Michael Wooldridge, John Wiley & Sons, 2007.

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YEAR 2--SEMESTER III

ELECTIVE COURSE 15a
Course code: MSCTEC305A
Course Title: Web Design & Web Data Analytics

Credit: 2

Course Objectives:

- ✓ To introduce students with advance web technologies.
- ✓ To train students to develop real time web applications.
- ✓ To train students to enhance the ranking of websites
- ✓ To train students to introduce security features to websites.

UNIT	TOPICS
Unit I	Introduction and Web Development Strategies, History of Web and Internet, Protocols governing Web, Writing Web Projects, Connecting to Internet, Introduction to Internet services and tools, Introduction to client-server computing, HTML: list, table, images, frames, forms, CSS, Document type definition, XML: DTD, XML schemes, Object Models, presenting and using XML
Unit II	Using XML Processors: DOM and SAX, Dynamic HTML, Introduction to active server pages (ASP), Introduction to Java Server Page (JSP), JSP Application Design, JSP objects, Conditional Processing, declaring variables and methods, Sharing data between JSP pages. Multimedia Objects, Multimedia in business and work, Multimedia hardware, Memory & Storage devices, Communication devices, Presentation tools, object generation which includes video sound; image capturing, Authoring tools, card and page-based authoring tools
Unit III	Web Analytics- Present and Future, History of Web Analytics, Current Landscape and Challenges, What Web Analytics Should Be Data Collection—Importance and Options: Understanding the Data Landscape, Click stream Data, Outcomes Data, Research Data, and Competitive Data. Web Analytics Fundamentals: Capturing Data: Web Logs or JavaScript tags? Selecting Your Optimal Web Analytics Tool, Understanding Clickstream Data Quality, Implementing Best Practices, Apply the "Three Layers of So What" Test
Unit IV	Understanding Standard Reports, Using Website Content Quality and Navigation Reports. Creating Foundational Reports, E-commerce Website, Support Website, Blog Measurement Search Analytics- Internal Search, SEO, and PPC Performing Internal Site Search Analytics, Beginning Search Engine Optimization, Measuring SEO Efforts, Analysing Pay per Click Effectiveness. Website Experimentation and Testing- Shifting the Power: Why Test and What Are Your Options? What to Test, Building a Experimentation and Testing Program

REFERENCE BOOKS:	
1.	"Web Enabled Commercial Application Development using HTML, JavaScript, DHTML and PHP", Ivan Bayross, BPB Publication, 2016
2.	"Multimedia: Making it Work", Tay Vaughan, 8th Edition, McGraw Hill Education, 2011
3.	"Web Analytics: An Hour a Day" Avinash Kaushik, Sybex, 2007
4.	"Actionable Web Analytics: Using Data to Make Smart Business Decisions", Jason Burby and Shane Atchison, Sybex, 2007

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YEAR 2--SEMESTER III

ELECTIVE COURSE 15b
Course code: MSCTEC305B
Course Title: Software Engineering

Credit: 2

Course Objectives:

- ✓ To understand the concept of software design process.
- ✓ To understand the different phases of software design.
- ✓ To develop vulnerability free software.
- ✓ To validate and verify different software design phases.

UNIT	TOPICS
Unit I	Introduction to System Engineering, A layered technology, A process framework, Systems and their Environment, Process models and System Modelling, System Engineering Process, System Procurement.
Unit II	Software Processes: Software Process Models, Process Iteration, Software Specification, Design and Implementation, Building the analysis model, Software Requirements: Functional and Non-Functional Requirements, User Requirements, System Requirements, Software Requirements Document, Requirements Engineering Processes
Unit III	Feasibility Studies, Requirements Elicitation and Analysis, Requirements Validation, Requirements Project Management, Project planning, Project scheduling, Design within the context of Software Engineering, Design concerts, Design models, Pattern-based software design.
Unit IV	Software architecture, data design, Architectural styles and patterns, Architectural design, mapping dataflow into software architecture, User interface analysis and design, Verification and Validation: Verification and Validation Planning, Software Inspections, Automated Static Analysis, Clean-room Software Development Software Testing: Defect Testing, Integration Testing, Object-Oriented Testing, Testing Workbenches, Software Cost estimation, availability and Reliability

REFERENCE BOOKS:

1.	"Software Engineering", Ian Sommerville, Addison Wesley Publication, 2000.
2.	"Software Engineering", Roger S. Pressman, Tata McGraw-Hill Publication, 2010.
3.	"Software Engineering", K. K. Aggarwal and Y. Singh, New Age publication, 2008.

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YEAR 2–SEMESTER III

ELECTIVE COURSE 15c Course code: MSCTEC305C Course Title: Ethical & Responsible AI	
Credit: 2	
Course Objectives: ✓ To automate human tasks. ✓ To seek the application possibilities of AI in society and humanity. ✓ To understand the ethical use of AI. ✓ To increase the accuracy of AI based decisions.	
UNIT	TOPICS
Unit I	Definition of morality and ethics in AI, Impact of AI on society, Impact on human psychology, Impact on the legal system, Impact on the environment and the planet, Impact on trust Ethical AI and Responsible AI
Unit II	Ethical initiatives in AI: International ethical initiatives-Ethical harms and concerns-Case study: healthcare robots, Autonomous Vehicles, Warfare and weaponization.
Unit III	AI standards and regulation: Model Process for Addressing Ethical Concerns during System Design, Transparency of Autonomous Systems, Data Privacy Process-Algorithmic Bias Considerations- Ontological Standard for Ethically Driven Robotics and Automation Systems
Unit IV	Social and ethical implication of robotics, Roboethics: Robot- Ethics and Morality-Moral Theories, Ethics in Science and Technology, Ethical Issues in an ICT Society-Harmonization of Principles- Ethics and Professional Responsibility- Roboethics Taxonomy. Artificial Intelligence and ethics- challenges and opportunities, ethical issues in artificial intelligence, Societal Issues, Ethics- considering application of Artificial Intelligence in Medicine, decision-making role in industries-National and International Strategies on AI
REFERENCE BOOKS:	
1.	"Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way" Virginia Dignum, Springer Nature, 2019
2.	"Interpretable Machine Learning" Christoph Molnar Lulu, 2019

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YEAR 2–SEMESTER III

Internship Field Work Course code: MSCTIW306 Course Title: Internship Field Work
Credit: 2
Course Objectives: ✓ Apply theoretical knowledge to real-world scenarios. ✓ Develop industry-specific skills and competencies. ✓ Gain insight into workplace dynamics and professional practices. ✓ Network with industry professionals and build career connections. ✓ Enhance problem-solving, communication, and teamwork abilities. ✓ Reflect on their career goals and align academic learning with industry demands.
As per the Guidelines provided in the NEP Ordinances