DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY CHHATRAPATI SAMBHAJINAGAR

Curriculum under Choice Based Credit & Grading System

Revised Syllabus of Bachelor of Engineering

3rd Year

Artificial Intelligence and Machine learning Under the Faculty of Science &Technology

[Effective from the Academic Year 2025-26 & onwards/-]

12/07/2025

PROF. (DR). R.R.DESHMUKH
DIRECTOR
INTERNATIONAL CENTRE OF EXCELLENCE
IN ENGG. & MGMT. CHH.SAMBHAJINAGAR.

HEAD OF DEPARTMENT
Computer Science & Engineering
MIT, Aurangabad
Incharge - Chairperson

Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHH. SAMBHAJI NAGAR

FACULTY OF SCIENCE AND TECHNOLOGY

Board of Studies in Artificial Intelligence and Machine Learning

The curriculum structure of TE Artificial Intelligence and Machine learning

PART-I

Sub Code	Semester-I	Contact Hrs/Week				Examination Scheme						Duration of The Theory Examination
	Subject	L	T	P	Total	CT	TH	TW	PR	Total	credits	
AIM301	Systems Programming	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM302	Theory of Automata	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM303	Computer Network	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM304	Programming in JAVA	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM341 AIM342 AIM343	Elective–I	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM321	Lab1:Computer Network	--	--	2	2	--	--	--	50	50	1	
AIM322	Lab2:Programming in JAVA	--	--	2	2	--	--	--	50	50	1	
AIM323 AIM324 AIM325	Lab3:Elective–I	--	--	2	2	--	--	50	--	50	1	
AIM326	Lab4:Python Programming-II		--	2	2	--	--	--	50	50	1	
BSH305	Communication Skills-II	2	--	--	2	--	--	50	--	50	2	
	Total	**22**	**--**	**8**	**30**	**100**	**400**	**100**	**150**	**750**	**26**	

Elective I :

Code	Elective-I
AIM341	Information Theory
AIM342	Image Processing
AIM343	High-Performance Computing

PART-II

Sub Code	Semester-II	Contact Hrs/Week				Examination Scheme						
	Subject	L	T	P	Total	CT	TH	TW	PR	Total	Credits	Duration of The Theory Examination
AIM351	Natural Language Processing	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM352	Software Engineering	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM353	Data Warehousing and Data Mining	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM354	Advance ML	4	--	--	4	20	80	--	--	100	4	3 Hrs
AIM391 AIM392 AIM393	Elective-II	4	--	--	4	20	80	--	--	100	4	3Hrs
AIM371	Lab5:NLP	--	--	2	2	--	--	--	50	50	1	
AIM372	Lab6: Software Engineering	--	--	2	2	--	--	50	--	50	1	
AIM373	Lab7:Data Warehousing and Data Mining	--	--	2	2	--	--	--	50	50	1	
AIM374 AIM375 AIM376	Lab8 Elective-II	--	--	2	2	--	--	50	--	50	1	
AIM377	Lab9 SDL-II (Android)	--	--	4	4	--	--	--	50	50	2	
	Total of Semester II	**20**	**--**	**12**	**32**	**100**	**400**	**100**	**150**	**750**	**26**	
	Total of Semester I & II	**42**		**20**	**62**	**200**	**800**	**200**	**300**	**1500**	**52**	

Elective II:

Code	Elective-II
AIM391	Cryptography and network security
AIM392	Pattern Recognition
AIM393	Game Architecture & Design

L: Lecture hours per week, **T**: Tutorial hours per Week, P: Practical hours per week, **CT**: Class Test, **TH**: University Theory Examination, **TW**: Term Work, **PR**: Practical/Oral Examination

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM301
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Systems Programming
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite

Data structures and Operating System

Objectives

Students will be able to

1. Understand concepts of system programming, machine language and assembly language
2. Understand concepts of lexical, syntax and semantic analysis
3. Understand assemblers, macros and macro call
4. Understand compilers, loaders, linkers, interpreters and debuggers

CONTENTS

SECTIONA

Unit-1. Introduction to System Programming **(10 hrs)**

Concept, historical development, components of system software, life cycle of source program, Programming languages and language processors, fundamentals of language processing, symbol table, foundation of system software.

Unit-2. Assembler **(08 hrs)**

General design procedure, design the assembler, types of assemblers, one pass assembler, advanced assembly process, design of two pass assembler

Unit-3. Macro language and Macro processors **(12 hrs)**

Macro instructions, features of macro facility, macro instruction arguments, conditional macro expansion, macro call within macros, macro instruction defining macros Implementation-Implementation of restricted faculty: two pass algorithm, single pass algorithm, implementation of macro calls within macros, implementation within assembler.

SECTIONB

Unit-4. Loaders and Linkers **(10hrs)**

Loaders scheme : "compile and go loaders", general loader schemes, absolute loaders, subroutine linkages, relocating loaders, direct linking loaders, other loader schemes, binders, linking loaders overlays, dynamic binders. Design of absolute loaders, design of direct linking loaders, linkers vs loaders.

Unit-5. Scanning and Parsing **(10hrs)**

Programming language grammar, classification of grammar, ambiguity in grammatic specification, scanning, parsing, top down and bottom up parsing, language processor development tools

Unit- 6. Compilers, Interpreters and Debuggers **(10hrs)**

Causes of large semantic gap, binding and binding times, data structure used in compiling scope rules, memory allocation, compilation of expression, compilation of control structure, code optimization. Benefits of interpretation, overview of interpretation, classification of debuggers, dynamic/interactive debugger.

Text Books

1. John J. Donovan, 'System Programming',Tata Mc- Graw Hill.
2. D. M. Dhamdhere, 'System Programming and operating system',Tata Mc- Graw Hill.
3. G. Sudha Sadashiv, 'Compiler design', SciTech.
4. Rajesh K. Maurya,'System Programming',Dreamtech.

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Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM302
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Theory of Automata
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Discrete mathematics

Objectives:

1. To introduce the fundamental concepts of formal languages, grammar, and automata theory.
2. To study and develop fundamentals for computational theory.
3. To apply abstract models for solving problems in computing.
4. To understand the differences between decidability and undecidability

CONTENTS

SECTIONA

Unit1: Finite Automata **[10hrs]**

Introduction to Finite Automata, Structural representation, Automata and complexity. Chomsky Classification of languages, Central Concepts of Automata Theory, Deterministic Finite Automata, Nondeterministic Finite automata, FA with epsilon transitions, Applications of FA, FA with output: Moore and Mealy machine

Unit 2: Regular Expressions and Languages **[12hrs]**

Regular Expressions, Finite automata, and Regular Expression, Algebraic laws for RE, Arden theorem, Pumping lemma for Regular languages, Applications of pumping lemma, Closure and Design properties of regular languages, Equivalence and minimization of Automata, Applications of Regular Expressions.

Unit 3: Context-Free Grammars and Languages **[8 hrs]**

Context Grammars, Parse trees, Applications of CFG, Ambiguity in grammars and languages, Normal Forms for CFG: Chomsky Normal Form

SECTIONB

Unit 4: Pushdown Automata and LBA **[10hrs]**

Pushdown Automata – Definition, Languages of PDA, Acceptance by Empty Stack and Final State, Equivalence of PDA and CFG, Deterministic Pushdown Automata, Pumping lemma for CFL, The model of linear bounded Automata.

Unit 5:Turing Machine **[10hrs]**

The Turing machine–Notation for TM, Instantaneous description for TM, Transition diagram for TM, The language of a TM, Design of Turing Machines, Church Turing Thesis, TM and halting, Extensions to the basic TM: Multi tape TM, Nondeterministic TM, Universal TM.

Unit 6: Decidability and Undecidability **[10hrs]**

Decidable problems, Decidable problems concerning Regular Language, Undecidable Problems, and Simple Un-decidable Problems: Post Correspondence Problem, Intractable Problems: Classes P and NP.

Text Books:

1. JohnE.Hopcroft, Rajeev Motwani, Jeffrey.Ullman, "Introduction to Automata Theory Languages, and Computation" 3rd ed. , Pearson Education, ISBN: 81-317-1429-2
2. K.L.P. Mishra, N. Chandrasekaran, "Theory of Computer Science: Automata, Languages and Computation" 3rd ed. , PHI , ISBN : 978-81-203-2968-3
3. John C Martin, "Introduction to Languages and the Theory of Computation",3rded.,Tata McGraw Hill, ISBN: 0-07-066048-4)

Reference Books:

1. Michael Sipser , Introduction to the Theory of Computation, CENGAGE Learning, 3rd Edition ISBBN-13:978-81-315-2529-6.
2. Basavaraj S. Anami, KaribasappaK.G., "Formal Languages and Automata Theory" Wiley Publication, ISBN: 978-81-265-2010-7

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM303
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Computer Networks
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Computer Fundamentals
2. Data Communication

Objectives:

1. To learn and understand various Networking Protocols & Layers.
2. To understand functioning of a complete network.
3. To study most widely used computer network technologies in detail: Ethernet, TCP/IP.

CONTENTS
SECTION-A

Unit 1: Introduction [10 Hours]

Uses of Computer Networks, Networks, network types, Internet History, Network Hardware , Transmission Media: Twisted pair, coaxial cable, fiber optics cable, Devices: Repeater, hub, switch ,bridge, router and gateway, Networks Software, Protocol layering, TCP/IP protocol suite, OSI model.

Unit 2: Physical Layer [10 Hours]

Data and signals, digital signals, transmission impairment, data rate limits, performance, Digitalto-Digital conversion (line coding, line coding schemes), Digital-to-Analog Conversion: ASK, FSK, PSK, Multiplexing, switching (Three Methods of Switching, Switching and TCP/IP Layers), Circuit-switched networks, Packet switching.

Unit 3:Data-Link Layer [10 Hours]

Nodes and links, services, two categories of links, two sub layers, link-layer addressing, DLC services Framing, Flow control, Error detection and correction: types of errors, redundancy, detection versus correction, block coding ,cyclic codes: Cyclic Redundancy Check(CRC), Media Access Control (MAC): Random access (ALOHA, CSMA, CSMA/CD, CSMA/CA),Ethernet Protocol, Standard Ethernet, Fast Ethernet (100 Mbps), Gigabit Ethernet

SECTION-B

Unit 4: Network Layer **[10 Hours]**

Network-layer services, packet switching, network-layer performance,IPv4 addresses, forwarding of IP packets, Internet Protocol (IP), ICMPv4, routing algorithms: Distance-Vector Routing, Link-State Routing, Path-Vector Routing, Congestion Control: General principles of congestion control, congestion control in Virtual Circuit, congestion control in Datagram, Internetworking: concatenated virtual circuit, connectionless internetworking

Unit 5: Transport Layer **[10 Hours]**

Transport-Layer Services, Transport-Layer Protocols: Services, Port Numbers, User Datagram Protocol UDP): User Datagram, UDP Services, UDP Applications, Transmission Control Protocol(TCP) : TCP Services, TCP Features, Segment, A TCP Connection, State Transition Diagram, Windows in TCP, Flow Control, Error Control, TCP Congestion Control, TCP Timers

Unit 6: Application Layer **[10Hours]**

World Wide Web and HTTP, File Transfer Protocol (FTP), Electronic Mail, Domain Name System (DNS).

Text Books:

1. Forouzan B, "Data communication and Computer Networks", 5th Edition, Tata McGraw Hill.
2. Andrew S. Tanenbaum, "Computer Networks", 5th Edition, Pearson Education

Reference Books:

1. William Stallings, "Data and Computer Communication", 8th Edition, Pearson Education,2007.
2. Larry L. Peterson & Bruce S. Davie, "Computer Networks: A Systems Approach", 4th Edition,Morgan Kaufmann Publishers
3. Forouzan B, "TCP/IP Protocol Suite", 4th Edition, Tata McGraw Hill.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM304
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Programming in JAVA
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Basics of programming languages.
2. Concepts of Object Oriented Programming languages.

Objectives:

The students will be able to:

1. Apply object-oriented features to store real-time entities.
2. Handle exceptions &implement multithreaded programs.
3. Implement database programming.
4. Design & implement GUI with event handling
5. Develop I/O & networking programs.

CONTENTS

SECTIONA

Unit 1: Introduction **[10Hrs]**

Features of Java, Java Virtual Machine, Byte Code, JIT Compiler, Class fundamentals, Declaring objects, Nested and Inner Classes, Introducing Methods, Constructors, Garbage Collection, Overloading Methods, Using Objects as Parameters, Returning Objects, Access Control, Understanding static & final keyword, Inheritance Basics, Using Super, Method Overriding, Abstract Classes, Using final keyword with inheritance, Arrays, Vectors, Strings, Wrapper classes, Using Command-Line Arguments

Unit 2: Packages & interfaces **[10Hrs]**

Packages: Defining a Package, Finding Packages and CLASSPATH, A Short Package Example, Access Protection, Importing Packages Study of Java.Lang & Java.util packages, **Interfaces:** Defining an Interface, Implementing Interfaces, Variables in Interfaces, Extending Interfaces, Multiple Inheritance

Unit 2: Exception Handling & Multi threaded Programming **[10Hrs]**

Exception handling fundamentals, Exception Types, Usingtry-catch, Multipletry-catch clauses, Nested try statements, throw, throws, finally, Built-in Exceptions, creating your own exception subclasses, The Java Thread Model, The Main Thread, Creating a Thread, Creating Multiple Threads, Using is Alive( ) and join( ), Thread Priorities, synchronization, Suspending, Resuming, and Stopping Threads.

SECTION-B

Unit 4: Java Database Connectivity **[8Hrs]**

Introduction, Types of JDBC Drivers, Driver interface & Driver Manager Class, Connection Interface, Statement Interface, Prepared Statement, Result Set, JDBC Program for executing Statements &processing Result Set, Using Prepared Statement

Unit 5: Applet, Event Handling and AWT **[12Hrs]**

Applet: Applet Basics, An Applet Skeleton, Simple Applet Display Methods, Using the Status Window, The HTMLAPPLET Tag, Passing Parameters to Applets, **Event Handling:** The Delegation Event Model, Event Classes, Sources of Events, Event Listener Interfaces, Handling Mouse and Keyboard Events, Adapter Classes, Introduction to AWT, AWT classes, Window, Creating a Frame Window in an Applet, Working with Graphics

Unit 6: Input / Output &Networking **[10Hrs]**

Input/ Output: I/O Basics, Reading Console Input, Writing Console Output, The Print Writer Class, Reading and Writing Files, The Stream Classes, The Byte Streams, The Character Streams, Object Serialization & deserialization, networking: Networking Basics, The Networking Classes and Interfaces, TCP/IP Client Sockets, TCP/IP Server Sockets, Datagram's

Text/Reference Books:

1. Herbert Schildt, The Complete Reference-Java2,(SeventhEdition),TataMcGrawHill
2. Steven Holzner, Java2Black Book, DreamTechPress
3. Deitel & Deitel, Java: Howto Program, PHI
4. Bert Bates, Kathy Sierra, Head First Java, O'Reilly Media, Inc.
5. E Balagurusamy, Programming with Java, TataMcGraw Hill

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FACULTY OF SCIENCE AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – I

Course Code: AIM341 | **Title: Information Theory (Elective-I)**

Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Objectives:

1. Understand the fundamental concepts of information and its quantification.
2. Learn about data compression techniques and their theoretical limits.
3. Analyze different communication channels and their capacities.
4. Study error detection and correction codes to improve communication reliability.

CONTENTS

SECTION-A

Unit 1: Introduction to Information Theory **[10 Hrs]**

History and Applications of Information Theory, Information Sources and Source Models, Concept of Information: Information Content, Self-Information, Entropy, Properties of Entropy, Joint Entropy, Conditional Entropy, Mutual Information

Unit 2: Source Coding and Data Compression **[10 Hrs]**

Source Coding Theorem, Prefix Codes, Kraft Inequality, Huffman Coding, Shannon-Fano Coding, Arithmetic Coding, Lempel-Ziv Coding

Unit 3: Channel Capacity and Communication Channels **[10 Hrs]**

Communication Channel Models: Noiseless and Noisy Channels, Channel Capacity Definition, Binary Symmetric Channel (BSC), Binary Erasure Channel (BEC), Channel Capacity Theorem, Channel Coding Theorem

SECTION-B

Unit 4: Error Control Codes **[10Hrs]**

Need for Error Control, Types of Errors, Linear Block Codes: Hamming Codes, Cyclic Codes, Convolution Codes and Decoding (Brief Overview)

Unit 5: Information Measures and Applications **[10 Hrs]**

Relative Entropy (Kullback-Leibler Divergence), Entropy Rate of a Stochastic Process, Differential Entropy, Rate-Distortion Theory (Introduction)

Unit 6: Advanced Topics in Information Theory **[10Hrs]**

Capacity of Gaussian Channels, Multiple Access Channels, Network Information Theory (Basic Concepts), Applications in Data Compression, Cryptography, and Machine Learning

Textbooks:

1. "Elements of Information Theory" by Thomas M. Cover and Joy A. Thomas
2. "Information Theory, Inference, and Learning Algorithms" by David J.C. MacKay
3. "Introduction to Information Theory and Data Compression" by Peter D. Johnson Jr.
4. "Information Theory and Reliable Communication" by Robert G. Gallager

Reference Books:

1. "Fundamentals of Information Theory and Coding Design" by Roberto Togneri and Christos Christopoulos
2. "Coding and Information Theory" by Steven Roman
3. "Principles of Digital Communication and Coding" by Andrew J. Viterbi and Jim K. Omura
4. "Network Information Theory" by Abbas El Gamal and Young-Han Kim (for advanced topics)

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FACULTY OF SCIENCE AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – I

Course Code: AIM342
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Image Processing (Elective-I)
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Engineering Mathematics, Algorithms

Objectives:

1. Understand image formation and the role the human visual system plays in the perception of grey and colour image data.
2. Describe various applications of image processing in various sectors like medical, defense, etc.
3. Learn the signal processing algorithms and techniques in image enhancement and image restoration.
4. Apply various image processing techniques to solve real-world problems.

CONTENTS

SECTION-A

Unit 1: Introduction and Digital Image Fundamentals **[10Hrs]**

Digital Image Fundamentals, Human visual system, Image as a 2D data, Image representation – Gray scale and Colour images, image sampling and quantization

Unit2: Image enhancement in Spatial domain **[10Hrs]**

Basic gray level Transformations, Histogram Processing Techniques, Histogram equalization, Histogram Matching, Spatial Filtering, Low pass filtering, High pass filtering, Mexican Hat Transformation,

Unit3: Filtering in the Frequency Domain **[10Hrs]**

Introduction to the Fourier transform and frequency domain concepts, Extension to functions of two variables, low pass filter, high pass filter, Laplace transformation, Image Smoothing, Image Sharpening, Homo-morphic filtering.

SECTION-B

Unit 4: Image Restoration and Reconstruction **[10Hrs]**

Various noise models, image restoration using spatial domain filtering, image restoration using frequency domain filtering, Estimating the degradation function, and Inverse filtering.

Colour Image Processing: Colour Fundamentals, Colour Models, Pseudo colour image processing

Unit 5: Image Compression **[10Hrs]**

Fundamentals of redundancies, Basic Compression Methods: Huffman coding, Arithmetic coding, Error-free compression, Lossy compression. LZW coding, JPEG Compression standard

Unit 6: Morphological Image Processing: **[10Hrs]**

Erosion, dilation, opening, closing, Basic Morphological Algorithms: hole filling, connected components, thinning, skeletons

Text books:

1. Digital Image Processing, 3rd Edition, by Rafael C Gonzalez and Richard E Woods. Publisher: Pearson Education

Reference books:

1. Milan Sonka, Vaclav Hlavav, Roger Boyle, —Image Processing, Analysis and Machine Vision‖, 2nd ed., Thomson Learning, 2001
2. Pratt W.K, —Digital Image Processing‖, 3rd ed., John Wiley & Sons, 2007
3. Digital Image Processing Using Matlab, Rafel C. Gonzalez and Richard E. Woods, Pearson
4. Education
5. Fundamentals of Digital Image Processing by Anil K Jain, PHI

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FACULTY OF SCIENCE AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – I

Course Code: AIM 343 | **Title: High Performance Computing (Elective-I)**

Teaching Scheme | **Examination Scheme**

Theory: 04 Hours/Week | **Class Test: 20 Marks**

Credits: 4 | **Theory Examination (Marks):80Marks**

Theory Examination (Duration):03 Hours

Prerequisite:

Students should have knowledge of the following concepts to learn this subject. Operating System, Computer Organization and Architecture, Microprocessor and Architecture, Data structure and algorithms, C & C++ programming.

Objectives:

1. Understand High-Performance Computing (HPC) system architectures and various computational models.
2. Learn the basics of CUDA programming.
3. Apply parallel execution models and methodologies for parallel programming and parallel application development.
4. Design and implement compute-intensive applications on the HPC platform.

CONTENTS

SECTION-A

Unit 1: Introduction Parallel Programming & Computing **[10Hrs]**

Era of Computing, Parallel Computing, Multiprocessors, and Multicomputer Architectures, Scalar VS Vector Processing, Multi vector and Superscalar Machines, Pipelined Processors, SIMD Computers, Conditions of parallelism, Program flow mechanisms, Types of Parallelism – ILP, PLP, LLP, Program Partitioning and scheduling.

Unit 2: Introduction to High-Performance Computing **[10Hrs]**

Era of Computing, Scalable Parallel Computer Architectures, towards low-cost computing, Network of Workstations project by Berkeley, Cluster Computing Architecture, Components, Cluster Middleware and SSI, Need for Resource Management and Scheduling, Programming Environments

Unit 3: Cluster Computing **[10Hrs]**

Clustering Models, Clustering Architectures, Clustering Architectures key factors, types of clusters, Mission critical vs. business Critical Applications, Fault Detection and Masking Algorithms, Check pointing, Heartbeats, Watchdog Timers, Fault recovery through Failover and Failback Concepts

SECTION-B

Unit 4: High-Speed Networks & Message Passing **[10Hrs]**

Introduction to High-Speed Networks, Lightweight Messaging Systems, Xpress Transport Protocol, Software RAID and Parallel File systems, Load Balancing Over Networks – Algorithms and Applications, Job Scheduling approaches, and Resource Management in Cluster

Unit 5: CUDA Programming **[10Hrs]**

Introduction to CUDA architecture for parallel processing, CUDA Parallelism Model, Foundations of Shared Memory, Introduction to CUDA-C, Parallel programming in CUDA-C, Thread Cooperation and Execution Efficiency, Constants memory and events, memory management, CUDA C on multiple GPUs, Hashing and Natural Parallelism, Scheduling and Work Distribution, Atomics, Barriers and Progress, Transactional Memory, Introduction to CUDA Programming, Thread Execution in CUDA Programming, Matrix Computing in CUDA Programming

Unit 6: Open CL Programming **[10Hrs]**

Introduction to Open-CL, Open-CL Setup, Basic Open-CL, Advanced Open-CL, Open-CL Matrix Programming, Open-CL Multi Threads programming, Shared-memory programming, Introduction to Open-MP Programming, parallel programming using Open-MP, Open-MP Programming for Matrix Computing.

Textbooks/Reference Books:

1. "High-Performance Cluster Computing: Architectures and Systems"by Rajkumar Buyya, Pearson Education India
2. "Introduction to High-Performance Computing for Scientists and Engineers" by Georg Hager and Gerhard Wellein, Chapman & Hall/CRC computational science series CRC Press
3. "Advanced Computer Architecture: Parallelism, Scalability, Programmability" by Kai Hwang, McGraw Hill International Editions
4. "Scientific Computing: An Introductory Survey (2nd ed.)," by Michael T. Heath, McGraw Hill Education (India) Private Limited, 2011

PATTERN OF QUESTION PAPER:

Six units in the syllabus shall be divided into two equal parts i.e. 3 units in each part. Question paper shall be set having two sections A and B. Section A questions shall be set on first part and Section B questions on second part. Question paper should cover the entire syllabus.

For 80 marks Paper:

1. Minimum ten questions.
2. Five questions in each section.
3. Question no. 1 from section A and Question no. 6 from section B, 10 marks each, will be compulsory.
4. From the remaining questions in section A and B students are supposed to solve any two questions, 15 marks each.

Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHH. SAMBHAJI NAGAR
FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM321
Teaching Scheme
Credits: 1

Title: LAB–1 Computer Networks
Examination Scheme
Practical/Oral Examination (Marks):50Marks
Practical/Oral Examination (Duration):03Hours

Suggestive List of Practical's:

1. Fundamental components of data communication

2. Networking device: repeater, hub, switch, router and gateway

3. Transmission media: Guided and Unguided media

4. Creating Networking cable using crimping tool and study of RS232 standard

5. Case Study 1: Working of Physical Layer for a) Standard Ethernet, b) Fast Ethernet, c) Gigabit Ethernet, Understanding Encoding- Bit rate, modulation, topology, mode of communication (Simplex, Half Duplex, Full Duplex) for each of Ethernet generations.

6. Case Study 2: Working of Data Link Layer for a) Standard Ethernet, b) Fast Ethernet, c) Gigabit Ethernet, Understanding Data Link Layer: Framing, Physical Addressing, Flow and Erro Control,MAC for each of Ethernet generations.

7. Creating workgroup of computers and resource sharing (file & printer) (Windows OS preferred)

8. Networking Commands: ifconfig, ping, tracert, netstat (Windows commands:pconfig, traceroute).

9. C Program for Routing Algorithm.

10. Any one of the following

a. Wireshark tool for capturing and analyzing network traffic

b. tcpdump command (Linux command) along with various options for capturing and analyzing network traffic.

11. FileZilla program for File Transfer Protocol

Note: It is compulsory for the Students to perform one additional application based on an assignment which should cover the maximum possible queries.

Practical Examination:
The internal examiner should conduct a practical Examination for three hours under the supervision of external examiner. External examiners should evaluate students by checking practical performance and conducting viva.

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Semester – I

Course Code: AIM322 **Title: LAB-2 Programming in Java**

Teaching Scheme
Practical: 02 Hours/week
Credits: 1

Examination Scheme
Practical/Oral Examination (Marks):50Marks
Practical/Oral Examination (Duration):03Hours

Suggestive List of Practical Assignments:

Design, develop, and implement the following Assignments.

1. 1.Write a program to demonstrate basic syntactical constructs of java.
    a. a>Operators & Expressions
    b. b>Looping Statement
    c. c>Decision Making Statement
2. Write a program to define a class, describe its constructor & overload its constructor.
3. Write a program to implement inheritance & demonstrate use of method overriding &various access controls.
4. Write a program to implement Multiple Inheritance with interfaces.
5. Write a program to create a package &use another program.
6. Write a program to implement exception handling using built-in & user-defined exceptions.
7. Write a program to implement concept of multithreading.
8. Write a program for database connectivity using JDBC.
9. Write a program using Applet to demonstrate parameter passing.
10. Write a program to implement event handling
11. Write a program to implement object Serialization & deserialization.
12. Write a program to implement socket programming.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM 323 | **Title: LAB-3: Information Theory :(Elective-I)**
Teaching Scheme | **Examination Scheme**
Practical: 02 Hours/Week | **Term work: 50 Marks**
Credits: 1

Suggestive List of Practical Assignments:

Information Theory:

1. Calculate entropy for different discrete probability distributions.
2. Compute joint entropy, conditional entropy, and mutual information from data.
3. Design and implement Huffman coding for given source data.
4. Simulate Shannon-Fano coding and compare it with Huffman coding results.
5. Implement Arithmetic coding on sample data sets.
6. Analyze the performance of the Binary Symmetric Channel (BSC) and calculate channel capacity.
7. Encode and decode messages using Hamming (7,4) code for error correction.
8. Simulate cyclic codes and demonstrate error detection and correction capabilities.
9. Explore compression ratios for different algorithms using sample files.
10. Estimate Kullback- Leibler divergence between two discrete distributions.

TERMWORK

The term work shall consist of at least 8 experiments/assignments based on the syllabus above. Assessment of term work should be done as follows:

- Continuous lab assessment.
- Actual practical performance in the Laboratory.
- An oral examination conducted (internally)at the time of submission.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: AIM 324 | **Title: LAB-3: Image Processing (Elective-I)**

Teaching Scheme
Practical: 02 Hours/Week
Credits: 1

Examination Scheme
Term work: 50 Marks

Suggestive List of Practical Assignments:
Implement the following Assignments using MATLAB/SCILAB/OCTAVE/JAVA

1. Image Enhancement using point processing methods

2 . Image Enhancement using spatial domain methods: Smoothing Filters, Sharpening Filters

3 . Image Enhancement using low pass filter in frequency domain methods: Low Pass Filters, High Pass Filters

4 . Demonstration of image compression Methods: Lossless Compression methods, Lossy Compression methods

5 . Demonstration of Image Segmentation Methods: Threshholding methods, Region Based Methods

6 . Morphological image operations- erosion, dilation, opening and closing.

7 . Programs for illustrating colour image processing

8. Programs for region description and boundary representation.

9.Programfor object recognition

10 . Case studies Guidelines for case studies:
1.Group of 2-3 Students should elect real life IP problem Domain And implement any of its DIP module., Problem Domains, Biometric Imaging , Medical imaging, Satellite imaging etc, IP Modules ,Image enhancement, Image Segmentation etc

TERMWORK

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Semester – I

Course Code: AIM325 **Title: LAB-3 High Performance Computing (Elective-I)**

Teaching Scheme
Practical: 02 Hours/Week
Credits: 1

Examination Scheme
Term work: 50 Marks

Suggestive List of Practical Assignments:

1. Matrix Multiplication using CPU Multithreading-Compare sequential and parallel matrix multiplication using threads.
2. Parallel Merge Sort using Multithreading- Implement merge sort with thread-based parallelism.
3. Cluster Job Scheduling Simulation-Simulate job scheduling using Round Robin or Priority scheduling.
4. Heartbeat Mechanism for Fault Detection in Cluster- Simulate failure detection between nodes using heartbeat exchange.
5. CUDA Program: Vector Addition-Write a basic CUDA C program to add two vectors in parallel.
6. Matrix Multiplication using CUDA C- Implement matrix multiplication using CUDA and compare speedup.
7. CUDA Image Processing: Invert Image Colours- Load the image and use CUDA threads to invert pixel values.
8. Open-CL Program: Matrix Multiplication-Use Open-CL kernels to perform matrix multiplication on GPU.
9. Open-MP Program: Matrix Multiplication-Use `#pragmaomp parallel` to parallelize matrix operations.
10. Open-MP Program: Find the Maximum Value in Array-Parallel reduction to find the max element using Open-MP

TERMWORK

The term work shall consist of at least 8 experiments/assignments based on the syllabus above. Assessment of term work should be done as follows:

- Continuous lab assessment.
- Actual practical performance in the Laboratory.
- An oral examination conducted (internally)at the time of submission.

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Semester – I

Course Code: AIM326
Teaching Scheme
Credits: 1

Title: Lab 4 Python Programming-II
Examination Scheme
Practical/Oral Examination (Marks):50Marks
Practical /Oral Examination (Duration):03Hours

List of Suggestive Experiments

Design, develop, and implement the following assignments using Android Studio/Visual Studio xamarin.

Practical No. 1:

a) Running Instructions In Interactive Interpreter
b) Write A Program To Purposefully Raise Indentation Error And Correct It
c) Write A Program To Compute Distance Between Two 15

Practical No. 2:

a) Points Taking Input From The User (Pythagorean 2 Theorem)
b) Write A Program Add. Py That Takes 2 Numbers As Command Line Arguments And Prints Its Sum.
c) Write A Program For Checking Whether The Given Number Is A Even Number Or Not.

Practical No. 3:

a) Using A For Loop, Write A Program That Prints Out The Decimal Equivalents Of 1/2, 1/3, 1/4, . . . , 1/10
b) Write A Program Using A For Loop That Loops Over A Sequence. What Is Sequence?
c) Write A Program Using A While Loop That Asks The 21 User For A Number, And Prints A Countdown From That Number To Zero.

Practical No. 4:

a) Find The Sum Of All The Primes Below Two Million. Each New Term In The Fibonacci Sequence Is 23 Generated By Adding The Previous Two Terms. By Starting With 1 And 2, The First 10 Terms Will Be: 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, ... By Considering The Terms In The Fibonacci Sequence Whose Values Do Not Exceed Four 24 Million, Find The Sum Of The Even-Valued Terms.
b) Write A Program To Print Each Line Of A File In Reverse Order

Practical No. 5:

a) Write A Program To Compute The Number Of Characters, Words, And Lines In A File.
b) Write A Function Ball_ Collide That Takes Two Balls As Parameters And Computes If They Are Colliding. Your Function Should Return A Boolean Representing Whether Or Not The Balls Are 9 Hint: Represent A Ball On A Plane As A Tuple Of (X, Y, R), R Being The Radius If (Distance Between Two Balls Centers) <= (Sum Of Their Radii) Then (They Are Colliding)

Practical No. 6:

a) Find the Mean, Median, and Mode For The Given Set Of Numbers In A-List.
b) Write A Function Nearly_ Equal To Test 32 Whether Two Strings Are Nearly Equal.
c) Two Strings A And B Are Nearly Equal When A Can Be Generated By A Single Mutation On B.

Practical No. 7:

a) Write A Function Dups To Find All Duplicates In The List
b) Write A Function Unique To Find All The Unique Elements Of A List. Functions –
c) Write A Function Cumulative_ Product To Compute the Cumulative Product Of A List Of Numbers.

Practical No. 8:

a) Write A Function Reverse To Reverse A List. Without Using The Reverse Function.

b) Write Function To Compute Gcd, Lcm Of Two Numbers. Each Function Shouldn't Exceed One Line
c) Write A Program That Defines A Matrix And Prints

Practical No. 9:

a) Write A Program To Perform the Addition Of Two Square Matrices
b) Write A Program To Perform Multiplication Of Two Square Matrices Gui, Graphics

Practical No. 10:

a) Write A Gui For An Expression Calculator Using Tk 18
b) Write A Program To Implement The Following Figures Using Turtle

MINI PROJECT (Compulsory): Students have to submit a mini-project at end of the semester with a report in a group of maximum of 3 students

Practical Examination:

Internal examiner should conduct practical Examination for three hours under the supervision of external examiner. External examiner should evaluate student by checking practical performance and conducting viva.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – I

Course Code: BSH305
Teaching Scheme
Theory: 02Hours/Week
Credits: 2

Title: Communication Skill-II
Examination Scheme
Term Work: 50Marks

Prerequisite:

1. Basic Knowledge of Soft Skills
2. Good understanding of English

Objectives:

1. To imbibe leadership skills
2. To develop interpersonal Skills
3. To introduce corporate etiquettes
4. To imbibe team skills

CONTENTS

Unit 1: Understanding self and Goal setting **(8Hours)**
Self-Assessment: Understanding Self Core Competency (SWOT/SWOC), Long and short-term Goal-setting Execution Skills

Unit 2: Interpersonal Skills **(7Hours)**
Interpersonal communication, Conflict Management, Problem-Solving, Decision Making Persuasion and Influence

Unit 3: Group Dynamics and Team Building **(8Hours)**
Group vs. Team, Team Building, Team Work, Developing Leadership Skills

Unit 4: Corporate Etiquette **(7Hours)**
Clothing Etiquette, Personal hygiene and grooming, time management, Influencing Skills (Impression) Balancing personal and professional Life, Ethics, Values and Laws

Textbook:

1. The Ace of Soft Skills (Gopal aswamy Ramesh) Pearson Publication

Reference Books:

1. Execution;:Ram Charan
   (Publisher: Crown Business;1 edition(June15, 2002)
   Language: English ISBN-10:0609610570ISBN-13: 978-0609610572
2. Laws of Teamwork: John C Maxwell
3. Master of Business Etiquette: Cyrus Gonda
   (Author: Cyrus Gonda, Publisher EMBASSYBOOKS,2017, ISBN 9385492721,9789385492723)
4. Goals :

(Author: Brain Tracy ISBN:1-57675-235-6 Published by Berrett-Koehler Publishers,Inc)

5. Interpersonal Skills at work :
(Author: John Hayes Second Edition: Rout ledge)

6. People Smart :
(Author: Freda Hans burg by Berrett- Koehler Publishers, Inc)

Term Work Assessment (50marks):
The term work shall consist of internal online examination of 50 Marks, conducted at institute level. The marks of the examination shall be forwarded to the University.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – II

Course Code: AIM351
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Natural Language Processing
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Objectives:

1. To Learn the fundamentals of NLP, and also to make them for understanding CFG, PCFG in NLP.
2. To know the role of semantics of sentences and pragmatics.
3. To teach the basic concepts of speech processing along with analysis and modeling.

CONTENTS

SECTION-A

Unit 1: Introduction **[10Hours]**

Origins and challenges of NLP – language modelling : grammar-based lm, statistical lm –regular expressions, finite-state automata – English morphology, transducers for lexicon and rules, tokenization, detecting and correcting spelling errors, minimum edit distance

Unit 2: Word Level Analysis **[10Hours]**

Unsmoothed n-grams, evaluating n-grams, smoothing, interpolation and back-off – word classes, part-of-speech tagging, rule-based, stochastic and transformation-based tagging, issues in pos tagging – hidden Markov and maximum entropy models.

Unit 3: Syntactic Analysis **[10Hours]**

A context-free grammar, grammar rules for English tree banks, normal forms for grammar – dependency grammar – syntactic parsing, ambiguity, dynamic programming parsing – shallow parsing – probabilistic cfg, probabilistic cyk, probabilistic lexicalized cfgs – feature structures, unification of feature structures.

SECTION-B

Unit 4: Semantics and Pragmatics **[10Hours]**

Requirements for representation, first-order logic, description logics – syntax-driven semantic analysis, semantic attachments – word senses, relations between senses, thematic roles, selectional restrictions – word sense disambiguation, wsd using supervised, dictionary & thesaurus, bootstrapping methods – word similarity using a thesaurus and distributional methods.

Unit 5: Basic Concepts of Speech Processing **[10Hours]**

Speech fundamentals: articulatory phonetics – production and classification of speech sounds; acoustic phonetics – acoustics of speech production; review of digital signal

processing concepts; short-time Fourier transform, filter- bank and LPC methods.

Unit 6: Speech-Analysis, Speech Modeling **[10Hours]**

Features, feature extraction, and pattern comparison techniques: speech distortion measures– mathematical and perceptual – log–spectral distance, cepstral distances,

weighted cepstral distances and filtering, likelihood distortions, spectral distortion using a warped frequency scale, lpc, plp and mfcc coefficients, time alignment and

normalization – dynamic time warping, multiple time – alignment paths. Hidden Markov models: Markov processes, hmms – evaluation, optimal state sequence – Viterbi search, baum-welch parameter re-estimation, implementation issues.

.

Text Books:

1. Daniel Juraf sky, James H. Martin—Speech and Language Processing: "An Introduction to Natural Language Processing, Computational Linguistics and Speech", Pearson Publication, 2014.
2. Steven Bird, Ewan Klein and Edward Loper , —"Natural Language Processing with Python", First Edition, O Reilly Media, 2009.
3. Lawrence Rabiner And Biing-Hwang Juang, "Fundamentals Of Speech Recognition", Pearson Education, 2003.
4. Daniel Jurafsky And James H Martin, "Speech And Language Processing – An Introduction To Natural Language Processing, Computational Linguistics, And Speech Recognition", Pearson Education, 2002

Reference Books:

1. Frederick Jelinek, "Statistical Methods Of Speech Recognition", MIT Press, 1997.
2. Breck Baldwin, —Language Processing with Java and Ling Pipe Cookbook, Atlantic Publisher, 2015
3. Richard M Reese, —Natural Language Processing with Java, O Reilly Media, 2015.

PATTERN OF QUESTION PAPER:

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For 80 marks Paper:

1. Minimum ten questions.
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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – II

Course Code: AIM352 | **Title: Software Engineering**
Teaching Scheme | **Examination Scheme**
Theory: 04 Hours/Week | **Class Test: 20 Marks**
Credits: 4 | **Theory Examination (Marks):80Marks**
Theory Examination (Duration):03 Hours

Prerequisite:

1. StudentsshouldhavepriorbasicknowledgeonSoftwareattributes,Processmodels.
2. Students should have some basic knowledge on Testing, Maintenance.

Objectives:

1. This course is intended to provide the students with an overall view over Software Engineering discipline and with insight into the processes of software development.
2. To learn about generic models of software development process.
3. To understand the different design techniques and their implementation.
4. To learn various testing and maintenance measures.

CONTENTS
SECTION-A

Unit 1: Software Engineering–Overview **[10Hrs]**

Introduction–Characteristics of Software Engineering, FAQs about software engineering – Professional and ethical responsibility – Socio-Technical systems – emergent system properties – System Engineering – Organizations – people and computer systems–Legacy systems.

Unit 2: Software Process Models **[12Hrs]**

The Evolving role of Software – Software – The Changing Nature of Software – Legacy software — A generic view of process– A layered Technology – A Process Framework – The Capability Maturity Model Integration (CMMI) – Process Assessment – Personal and Team Process Models–Product and Process–Process Models– The Waterfall Model– Incremental Process Models – Incremental Model – The RAD Model – Evolutionary Process Models–Prototyping–The Spiral Model–The Concurrent Development Model– Specialized Process Models – the Unified Process.

Unit 3: Requirement Engineering **[8Hrs]**

Software Engineering Practice – communication Practice – Planning Practice modelling practice– Construction Practice Deployment. Requirements Engineering Requirements Engineeringtasks– InitiatingtherequirementsEngineeringProcess-ElicitingRequirement Developing Use cases –Building the Analysis Models–Elements of the Analysis Model– Analysis pattern – Negotiating Requirements – Validating Requirements.

SECTION-B

Unit 4: Analysis Modeling **[10Hrs]**

Requirements Analysis – Analysis Modeling approaches – data modeling concepts – Object-oriented Analysis – Scenario-based modeling – Flow-oriented Modeling – Class-based modeling – creating a behaviour model.

Unit 5: Design & Testing **[10Hrs]**

Design Engineering – Design process -Design Quality-Design model-User interface Design – Testing strategies- Testing Tactics - strategies Issues for conventional and object-oriented software-validation testing – system testing –Art of debugging – Project management

Unit 6: Quality Assurance **[10Hrs]**

Software evolution - Verification and Validation - Critical Systems Validation – Metrics for Process,ProjectandProduct-QualityManagement-ProcessImprovement–Risk Management Configuration Management – Software Cost Estimation

Textbooks:

1. Roger S. Pressman, Software Engineering: A Practitioner's Approach, Mc Graw Hill International edition, Seventh edition, 2009.
2. Ian Sommerville, Software Engineering, 8thEdition,Pearson Education,2008.

Reference Books:

1. Stephan Schach, Software Engineering, Tata Mc Graw Hill, 2007
2. Pfleeger and Lawrence Software Engineering: Theory and Practice ,Pearson Education, second edition, 2001
3. Software Engineering Principles and Practice by Waman. S. Jawadekar, Tata McGraw Hill,2004.

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DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY CHH. SAMBHAJI NAGAR

FACULTY OF ENGINEERING AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – II

Course Code: AIM353
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Data Warehousing and Data Mining
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:
1. Database Management Systems

Objectives:
1. To introduce basic principles, concepts and applications of data warehousing.
2. To introduce students to the basic concept of Data Mining & pre-processing.
3. To introduce a wide range of Association, classification, clustering, classification algorithms.
4. To introduce basic concept of BI.

CONTENTS

SECTION-A

Unit 1: Data Warehousing: **[8Hrs]**

Data Warehouse: Basic Concepts, A Multi-tiered Architecture, Enterprise Warehouse, Data Mart, Extraction, Transformation, and Loading, Metadata Repository.

Unit 2: Data Warehouse Modeling and Implementation: **[12Hrs]**

Data Cube: A Multidimensional Data Model, Stars, Snowflakes, and Fact Constellations: Schemas for Multidimensional Data Models, Dimensions: The Role of Concept Hierarchies ,Measures: Their Categorization and Computation, Typical OLAP Operations, A Starnet Query Model for Querying Multidimensional Databases, Indexing OLAP Data: Bitmap Index and Join Index, OLAP Server Architectures: ROLAP versus MOLAP versus HOLAP.

Unit 3: Data Mining: **[10Hrs]**

Introduction: Data, Types of Data, Data Mining Functionalities, Interestingness of Patterns, Classification of Data Mining Systems, Data Mining Task Primitives, Integration of a Data Mining System with a Data Warehouse, Issues, Data pre-processing.

SECTION-B

Unit 4: Association Rule Mining and Classification: **[12hrs]**

Mining Frequent Patterns, Associations and Correlations, Mining Methods, Mining various Kinds of Association Rules, Correlation Analysis, Constraint Based Association Mining, Classification and Prediction, Basic Concepts, Decision Tree Induction, Bayesian Classification, Rule Based Classification, Support Vector Machines, Regression Models.

Unit 5: Clustering: **[10Hrs]**

Introduction, Clustering, Cluster Analysis, Clustering Methods- K means, Hierarchical clustering, Agglomerative clustering, Divisive clustering Introduction to Web Mining: Web Content Mining, Web Structure Mining, Web Usage Mining.

Unit 6: Business Intelligence: **[8Hrs]**

Introduction, Business Intelligence, Business Intelligence tools, Business Intelligence Infrastructure, Business Intelligence Applications, BI versus Data Warehouse, BI versus Data Mining, Future of BI.

Text Books:

1. Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Third Edition, Elsevier Publication.
2. Paulraj Ponniah, Data Warehousing: Fundamentals for IT Professionals, Wiley Publication.

Reference Books

1. Business Intelligence: A Managerial Approach (2nd Ed.) Turban, Sharda, Delen, King, Wiley Publication
2. C. S. R. Prabhu: Data Warehousing Concepts, Techniques, Products and Applications, Prentice Hall of India.
3. Alex Berson, Stephan J. Smith: Data Warehousing, Data Mining and OLAP, Tata McGraw Hill Edition.

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FACULTY OF ENGINEERING AND TECHNOLOGY

Third Year Engineering (AI & ML)

Semester – II

Course Code: AIM354 | **Title: Advance Machine Learning**

Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Machine Learning, Probability Theory

Objectives:

1. Understand key machine learning paradigms, including supervised and unsupervised learning.
2. Apply advanced methods such as kernel techniques, Bayesian inference, and ensemble learning.
3. Analyze and implement dimensionality reduction and feature selection techniques.
4. Explore recent trends and real-world applications of machine learning in diverse domains.

CONTENTS

SECTIONA

Unit 1: Machine Leaning Concepts **[10Hrs]**

Key concepts, Supervised/Unsupervised Learning, Loss functions and generalization, Probability Theory, Parametric vs. Non-parametric methods, Elements of Computational Learning Theory Ensemble Learning, Bagging, Boosting, Random Forest

Unit 2: Kernel Methods **[10Hrs]**

Kernel Methods for non-linear data, Support Vector Machines, Kernel Ridge Regression, Structure Kernels, Kernel PCA, Latent Semantic Analysis

Unit 3: Bayesian methods **[10Hrs]**

Bayesian methods for using prior knowledge and data, Bayesian inference, Bayesian Belief Networks and Graphical models, Probabilistic Latent Semantic Analysis, The Expectation-Maximisation(EM)algorithm, GaussiProcesses.

SECTIONB

Unit 4: Dimensionality Reduction **[10Hrs]**

Dimensionality Reduction - CCA, LDA, ICA, NMF - Canonical Variates - Feature Selection vs. Feature Extraction

Unit 5: Filter Methods **[10Hrs]**

Filter Methods - Sub-space approaches - Embedded methods Low-Rank approaches - Recommender Systems .Application areas - Security - Business - Scientific

Unit 6: Recent trends **[10Hrs]**

Recent trends in supervised and unsupervised learning algorithm, dimensional reducibility, feature selection and extraction

Reference Books:

1.Pattern Recognition and Machine Learning, Christopher M. Bishop

2. John Shawe-Taylor and Nello Cristianini, Kernel Methods for Pattern Analysis.

3. The Elements of Statistical Learning, Springer 2009

4. Machine Learning Algorithms, 2nd Edition, Giuseppe Bona ccorso, Packt Publication

5. Tensor Flow Machine Learning, Nick McClure, Packt Publication

PATTERN OF QUESTION PAPER:

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – II

Course Code: AIM391
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Cryptography and Network Security (Elective-II)
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Computer fundamentals
2. Computer Networks

Objectives:

1. To understand fundamental concepts of computer networking and functionality of layered network architecture.
2. To understand wireless and mobile networking concepts
3. To apply networking concepts to various situations, classifying networks, and analyzes the performance of computer network infrastructure.

CONTENTS

SECTION-A

Unit 1 : Introduction to Security and Cryptography **[10Hrs]**

Security trends, Legal, ethical, and professional aspects of security, Need for security at multiple levels, Security policies and models of network security, Security attacks, services, and mechanisms, OSI security architecture

Unit 2: Classical Cryptography and Foundations **[10Hrs]**

Classical encryption techniques: ,Substitution techniques, Transposition techniques, Steganography, Foundations of modern cryptography: Perfect security ,Information theory, Product cryptosystem, Cryptanalysis

Unit 3: Symmetric Key Cryptography **[10Hrs]**

Mathematics of symmetric key cryptography:, Algebraic structures, Modular arithmetic, Euclid's algorithm, Congruence and matrices, Groups, rings, and fields, Finite fields, Symmetric key ciphers: SDES, DES – structure and strength, AES – design principles and evaluation criteria, RC4 – stream cipher, Block cipher modes of operation, Differential and linear cryptanalysis, Key distribution

SECTION-B

Unit IV : Public Key Cryptography **[10Hrs]**

Mathematics of asymmetric key cryptography: Primes, primality testing, factorization, Euler's totient function, Fermat's and Euler's theorems, Chinese remainder theorem, Exponentiation and logarithm, Asymmetric key ciphers: RSA, Diffie–Hellman key exchange, ElGamal cryptosystem, Elliptic curve arithmetic, Elliptic curve cryptography, Key distribution and management

Unit V: Message Authentication and Digital Signatures **[10Hrs]**

Authentication requirements and functions, MAC and Hash functions, Security of hash functions and MACs, SHA algorithms Digital signatures and authentication protocols, Digital Signature Standard (DSS), Entity authentication: Biometrics, Passwords, Challenge-response protocols, Authentication applications: Kerberos, X.509

Unit VI: System and Network Security Applications **[10Hrs]**

E-mail security: PGP, S/MIME, IP security, Web security, System security concepts: Intruders, Malicious software (viruses, worms, trojans), Firewalls – types and configuration

Text Books:

1. William Stallings – Cryptography and Network Security: Principles and Practice, Pearson Education, 7th Edition
2. Behrouz A. Forouzan – Cryptography and Network Security, McGraw Hill, 3rd Edition
3. AtulKahate – Cryptography and Network Security, Tata McGraw Hill, 3rd Edition

Reference Books:

1. Bruce Schneier – Applied Cryptography: Protocols, Algorithms, and Source Code in C, Wiley
2. Douglas R. Stinson – Cryptography: Theory and Practice, CRC Press
3. Charles P. Pfleeger& Shari Lawrence Pfleeger – Security in Computing, Pearson Education
4. Kaufman, Perlman, and Speciner – Network Security: Private Communication in a Public World, Pearson
5. Menezes, van Oorschot& Vanstone – Handbook of Applied Cryptography, CRC Press

PATTERN OF QUESTION PAPER:

Six units in the syllabus shall be divided into two equal parts i.e. 3 units in each part. Question paper shall be set having two sections A and B. Section A questions shall be set on first part and Section B questions on second part. Question paper should cover the entire syllabus.

For 80 marks Paper:

1. Minimum ten questions.
2. Five questions in each section.
3. Question no. 1 from section A and Question no. 6 from section B, 10 marks each, will be compulsory.
4. From the remaining questions in section A and B students are supposed to solve any two questions, 15 marks each.

Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHH. SAMBHAJI NAGAR
FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – II

Course Code: AIM392
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Pattern Recognition (Elective-II)
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Objectives:
This course covers the techniques and gain proficiency of pattern recognition that are fundamental to a wide variety of application areas such as medical research, biometrics, computer vision, etc.

CONTENT

SECTION-A

Unit 1: Basics of Probability, Random Processes and Linear Algebra(recap) **[10Hrs]**

Probability: independence of events, conditional and joint probability, Bayes-theorem Random Processes: Stationary and non-stationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra. (6) 2) Bayes Decision Theory: Minimum-error-rate classification. Classifiers, Discriminant functions, Decision surfaces. Normal density and discriminant functions. Discrete features.

Unit 2: Parameter Estimation Methods **[12Hrs]**

Maximum-Likelihood estimation: Gaussian case. Maximum Posteriori estimation. Bayesian estimation: Gaussian case. Unsupervised learning and clustering - Criterion functions for clustering. Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation. Gaussian mixture models, Expectation-Maximization method for parameter estimation. Maximum entropy estimation. Sequential Pattern Recognition. Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs. Nonparametric techniques for density estimation. Parzen-window method. K-Nearest Neighbour method.

Unit 3: Dimensionality reduction **[8Hrs]**

Principal component analysis - it relationship to Eigen analysis. Fisher discriminant analysis - Generalized Eigen analysis. Eigen vectors/Singular vectors as dictionaries. Factor Analysis, Total variability space - a dictionary learning methods. Nonnegative matrix factorization - a dictionary learning method.

SECTION-B

Unit 4: Linear discriminant functions & Artificial neural networks **[10Hrs]**

Gradient descent procedures, perceptron, Support vector machines - a brief introduction. Artificial neural networks: Multilayer perceptron – feed-forward neural network. A brief introduction to deep neural networks, convolutional neural networks, and recurrent neural networks.

Unit 5 : Non-metric methods for pattern classification **[10Hrs]**

Non-metric methods for pattern classification: Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART).

Unit 6: Application(s) **[10Hrs]**

Application(s): Face recognition – pre-processing, face detection algorithms, selection of representative patterns, classification algorithms, results, and discussion. (4)

Textbooks:

1. O. Duda, P.E.Hart and D.G. Stork, Pattern Classification, John Wiley, 2001
2. S.Theodoridis and K. Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009

Reference Books:

1. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
2. P.A Devijver and J. Kittler, Pattern Recognition: A Statistical Approach, Prentice-Hall International, Englewood Cliffs, NJ, 1980.
3. K. Fukunaga, Introduction to Statistical Pattern Recognition, 2nd Ed. Academic Press, New York, 1990.

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FACULTY OF SCIENCE AND TECHNOLOGY
Third Year Engineering (AI &ML)
Semester – II

Code: AIM393
Teaching Scheme
Theory: 04 Hours/Week
Credits: 4

Title: Elective-II Game Architecture & Design
Examination Scheme
Class Test: 20 Marks
Theory Examination (Marks):80Marks
Theory Examination (Duration):03 Hours

Prerequisite:

1. Basic visual design and basic scripting or programming skills
2. Moderatefluencyin2Dand3Danimationandgraphics packages
3. Awareness of game platforms and the technology

Objectives:

1. To familiarize with the process of game design and development
2. To learn the processes, mechanics, and issues design
3. To understand the architecture of game programming

CONTENTS

SECTION-A

Unit 1: Games and Video Games **[10Hrs]**

Introduction, Conventional Games Versus Video Games, Games for Entertainment, Serious Games, Designing and Developing Games: Key Components of Video Games, The Structure of a Video Game, Stages of the Design Process, Game Design Team Roles, Game Design Documents, The Anatomy of a Game Designer, The Major Genres, Understanding Your Player, Understanding Your Machine, Game Balance.

Unit 2: Game Concepts **[10Hrs]**

Getting an Idea, From Idea to Game Concept, Game Worlds, Creative and Expressive Play,

Character Development, The Goals of Character Design: The Relationship Between Player and Avatar, Visual Appearances, Character Depth, Audio Design

Unit 3: Storytelling and Creating the User Experience **[10Hrs]**

Key Concepts, The Storytelling Engine, Linear and Nonlinear Stories, Granularity,

Mechanisms for Advancing the Plot, Emotional Limits of Interactive Stories, Scripted Conversations and Dialogue Trees, When to Write the Story Player-Centric Interface Design, The Design Process, Managing Complexity, Interaction Models, Camera Models, Visual and Audio Elements, Input Devices, Navigation Mechanisms, Accessibility Issues, Allowing for Customization.

SECTION-B

Unit 4: Current Methods of Team Management **[10Hrs]**

The Current Development Model - The Origins of the Industry, The Trouble with Game Developers, The Problem Developer, Excessive Long Hours Mean an Unsuccessful Project, Exceptions to the Rule Roles and Divisions - Assigning Personnel, Improving Morale and the Working Environment, The Software Factory - What Is a Software Factory? Why Use a Software Factory? Solving Game Development Issues, organizing a Software Factory, Applying the Software Factory Structure and Methodology, The Suitability of a Software Factory, Milestones, and Deadlines: Procedures and "Process", Procedures: Where to use them? What Should Source Control Be Used For? The Importance of Information Transmission, Troubleshooting, The Future of the Industry

Unit 5: Architecture Design **[10Hrs]**

Initial Design, The Beginning, Hardware Abstraction, Sound Hardware Abstraction, Other Hardware, The Problem Domain, Thinking in Tokens, Use of Technology: the State of the Art, Blue-Sky Research, Reinventing the Wheel, Use of Object Technology, Building Blocks Initial Architecture Design: The Birth of an Architecture, Architectural Concepts, The Tier System, Architecture Design Development: The Development Process-Code Quality, Debugging and Module Completion, Types of Bugs, reusable Architecture, Documentation, Design First, Schedule, Catch Mistakes as You Go Along.

Unit 6: Game Analysis **[10Hrs]**

Game Analysis: Abdicating Authorship, Familiar Subject Matter, Safe Experimentation, Depth and Focus, Interface, Controlled Versus Autonomous Behavior, A Lesson to Be Learned.

Designing Design Tools., Desired Functionality, Scripting Languages, and Object Behaviors, Us Versus Them, The Best of Intentions, A Game Editor for All Seasons, and Play Testing.

Textbooks:

1. Fundamentals of Game Design Third Edition by Ernest Adams,(New Riders Games)
2. Game Architecture and Design by Andrew Rollings Dave Morris

Reference Books:

1. Game Design: Theory & Practice by Richard RouseIIII llustrations by Steve Ogden, Foreword by Noah Falstein
2. The Art of Game Design by Jesse Schell, Morgan Kaufmann Publication
3. Game Programming Patterns by Robert Nystorm

PATTERN OF QUESTION PAPER:

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FACULTY OF SCIENCE AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – II

Course Code: AIM371 | **Title: Lab 5 -Natural Language Processing**

Teaching Scheme | **Examination Scheme**

Credit: 1 | **Practical/Oral Examination: 50Marks**

Practical/Oral Examination (Duration):03 Hours

Suggestive List of Practical Assignments:

1. Write a Python NLTK program to remove stop words from a given text.
2. Write a Python NLTK program to split the text sentence/paragraph into a list of words.
3. Write a Python NLTK program to tokenize sentences in languages other than English.
4. Write a Python NLTK program to create a list of words from a given string.
5. Write a Python NLTK program to list down all the corpus names.
6. Write a Python NLTK program to get a list of common stop words in various languages in Python.
7. Write a Python NLTK program to find the definition and examples of a given word using.
8. Word Net. Write a Python NLTK program to find the sets of synonyms and antonyms of a given word.
9. Write a Python NLTK program to get the overview of the tag set, details of a specific tag in the tag set, and details on several related tag sets, using regular expression.
10. Write a Python NLTK program to find the number of male and female names in the names corpus. Print the first 10 male and female names.
11. Write a Python program to demonstrate Lemmatization with NLTK.
12. Write a Python program to demonstrate Stemming with NLTK.
13. Write a Python Program for NLP analysis of Restaurant reviews.
14. Write a program for Twitter Sentiment Analysis using Python.
15. Write a program for Sentiment Analysis using VADER TEXT.

Practical Examination:

The supervision of an external examiner. External examiners should evaluate students by checking practical performance and conducting viva.

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FACULTY OF SCIENCE AND TECHNOLOGY

Third Year Engineering (AI &ML)

Semester – II

Course Code: AIM372 | **Title: LAB 6- Software Engineering**

Teaching Scheme | **Examination Scheme**

Practical: 2 Hours/Week | **Term Work: 50 Marks**

Credit: 1

Suggestive List of Practical Assignments:

Design, develop and implement the following Assignments.

1. Prepare a Software Requirements Specification (SRS) document for a basic system (e.g., Library Management System).
2. Design Use Case Diagrams using UML for a proposed software system.
3. Create Class Diagrams using any modeling tool (e.g., Star-UML, Lucid chart).
4. Draw Sequence Diagrams for major functionalities of the system.
5. Design a Data Flow Diagram (DFD) (Level 0, 1, 2) for any existing or proposed application.
6. Write a Functional Requirement Document (FRD) for a small software product.
7. Implement a simple prototype using a GUI tool (Java-X, Tkinter , or VB.NET).
8. Develop a test plan and test cases (black-box and white box) for a sample application.
9. Perform Requirement Validation through stakeholder review/checklists.
10. Conduct risk analysis using a risk matrix for a given case study.
11. Calculate basic software metrics (defect density, code complexity, productivity).
13. Estimate cost and effort using the COCOMO model or Function Point Analysis.

Term Work:

The term Work shall consist of at least 8 experiments / assignments based on the suggestive list of practical assignments. Assessment of term work should be done as follows:

- Continuous lab assessment
- Actual practical performance in laboratory
- Oral examination conducted(internally) at the time of submission

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Semester – II

Course Code: AIM373 **Title: Lab 7- Data Ware Housing and Data Mining**
Teaching Scheme: **Examination Scheme:**
Practical: 02 Hours/Week **Practical /Oral Examination: 50 Marks**
Credit: 1 **Practical/Oral Exam (Duration):3 hrs.**

Suggestive List of Practical's /Assignments:

Design, develop, and implement the following Assignments by

1. To Study Different Types of data warehousing
2. Experiments on Summarization/generalization Techniques
3. Implementation of Star Data Warehouse Schema
4. Implementation of Snowflake Data Warehouse Schema
5. Implementation of Fact Constellation Warehouse Schema
6. Experiments on Associations Techniques
7. Classification Using Decision Trees
8. Classification Using *Bayesian*
9. Experiments on Clustering Techniques using k means
10. Case study

Practical Examination:

The internal examiner should conduct a practical Examination for three hours under the supervision of external examiner. External examiners should evaluate student by checking practical performance and conducting viva.

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Semester – II

Course Code: AIM374
Teaching Scheme:
Practical: 02 Hours/Week
Credit: 1

Title: LAB-8: Cryptography and Network Security (Elective –II)
Examination Scheme:
Term Work: 50 Marks

Suggestive List of Practical Assignments:

1. Implement Caesar Cipher / Shift Cipher
2. Write a program to encrypt and decrypt messages using Caesar cipher.
3. Implement Mono-alphabetic and Poly-alphabetic Cipher (e.g., Vigenère Cipher)
4. Develop encryption/decryption logic for substitution ciphers.
5. Implement Playfair Cipher
6. Encrypt and decrypt messages using the Playfair technique.
7. Implement Hill Cipher
8. Use linear algebra (matrices) for encryption and decryption.
9. Implement RSA Algorithm
10. Generate keys and demonstrate encryption and decryption using RSA.
11. Implement Diffie-Hellman Key Exchange Algorithm
12. Simulate secure key exchange between two parties.
13. Implement MD5 and SHA Hash Algorithms
14. Compute the hash of a given message using Python or Java.
15. Implement Digital Signature using RSA
16. Sign a message and verify its authenticity using RSA-based digital signatures.
17. Simulate DES and AES Encryption Algorithms
18. Use built-in libraries or write custom code for block ciphers.
19. Packet Sniffing and Analysis using Wire-shark
20. Capture network packets and analyze protocols (HTTP, TCP, SSL).

Term Work:

The term Work shall consist of at least 8 experiments/assignments based on the suggestive list of practical assignments. Assessment of term work should be done as follows:

- Continuous lab assessment
- Actual practical performance in laboratory
- Oral examination was conducted(internally) at the time of submission

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Semester – II

Course Code: AIM375 | **Title: LAB-8 Pattern Recognition (ELECTIVE-II)**

Teaching Scheme | **Examination Scheme**

Practical: 02 Hours/Week | **Term Work: 50 Marks**

Credit: 1

Suggestive List of Practical Assignments:

1. Bayes Classifier Implementation
2. Maximum Likelihood Estimation (MLE) for Gaussian Distribution
3. K-Means Clustering Algorithm
4. Gaussian Mixture Model using Expectation-Maximization (EM)
5. Principal Component Analysis (PCA) for Dimensionality Reduction
6. Fisher's Linear Discriminant Analysis (LDA)
7. Support Vector Machine (SVM) for Classification
8. Multilayer Perceptron (MLP) using Deep Learning Framework
9. Hidden Markov Model (HMM) for Sequence Data
10. Face Recognition using Eigen faces (PCA-based approach)

Term Work:

The term work shall consist of at least 8 experiments/assignments based on the syllabus above. Assessment of term work should be done as follows:

- Continuous lab assessment.
- Actual practical performance in the Laboratory.
- An oral examination conducted (internally)at the time of submission.

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Semester – II

Course Code: AIM376
Teaching Scheme
Practical: 2 Hours/Week
Credit: 1

Title: LAB-8: Game Architecture & Design (Elective-II)
Examination Scheme
Term Work: 50 Marks

Suggestive List of Practical Assignments:

1. Design a Game Concept Document
2. Develop a 2D Game Prototype Using a Game Engine (e.g., Unity, Godot)
3. Character Design and Animation
4. Create a Game Storyboard with Linear and Nonlinear Narrative
5. Design and Implement a Game User Interface (UI)
6. Audio Design – Add Sound Effects and Music to Game Scenes
7. Prototype a Game Level with Balanced Game play
8. Create a Playable Game World Map
9. Use Version Control (Git) for Collaborative Game Development
10. Conduct Play testing and Analyze User Feedback

NOTE: At least 08 experiments along with a mini application must be done in the semester.

Term Work:

The term work shall consist of at least 8 experiments/assignments based on the syllabus above. Assessment of term work should be done as follows:

- Continuous lab assessment.
- Actual practical performance in the Laboratory.
- An oral examination conducted (internally)at the time of submission.

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Semester – II

Course Code: AIM377
Teaching Scheme
Credit: 2

Title: Lab 9 Software Development Lab
(Mobile Application Development for Android)
Examination Scheme
Practical Exam (Marks):50
Practical/Oral Exam (Duration):3 hrs.

Prerequisite

1. Concepts in Object-Oriented Programming Language
2. Knowledge of XML

Objectives:

1. To know the difference between Android and another mobile development platform.
2. To understand how Android apps work through the life cycle, intents, manifests, etc.
3. Todevelopdifferentandroidappwithcompellinguserinterfacesusingmenus, layouts and Views.
4. To use Android API for data storage, retrieval, content providers, SMS, and Telephony.
5. Tap into location-based services and different sensors.

List of Suggestive Experiments

Design, develop, and implement the following assignments using Android Studio/Visual Studio xamarin.

1. Design and develop an Android Application to display "Hello World" using basic Widgets
2. Design and develop an Android Application to demonstrate the Activity Life Cycle
3. Design and develop Android Applications to demonstrate GUI by using different Layouts/widgets
4. Design and develop Android Application to demonstrate views in Android
5. Design and develop Android Applications to demonstrate Intents(Implicit/ Explicit)
6. Design and develop Android Application to demonstrate Broadcast Receivers/Services
7. Design and develop an Android Application to demonstrate Saving Files in External/Internal Storage
8. Design and develop Android Applications to demonstrate Content Providers
9. Design and develop Android applications to demonstrate SQ-Lite database (Dictionary, Quiz, etc.)
10. Design and develop Android applications to demonstrate Firebase operations(data push, retrieval, delete, update, etc.)
11. Design and develop Android Application to demonstrate My-SQL database
12. DesignanddevelopAndroidApplicationtodemonstrateuseofTelephony(Call/SMS)
13. DesignanddevelopAndroidApplicationtodemonstrateuseofBluetooth/wi-fi
14. Design and develop Android Application to demonstrate use of Google map API
15. Design and develop Android Application to play audio/video files
16. DesignanddevelopAndroidApplicationtodemonstratesensors(Accelerometer/Compass)

List of Suggestive Assignments

1. Develop an application for the Hospital(Patient/Doctor portal)
2. Develop an application for an online Quiz
3. Develop chat application

MINI PROJECT (Compulsory): Students have to submit a mini-project at the end of the semester with a report in a group of a maximum of 3 students

Practical Examination:
The internal examiner should conduct practical Examination for three hours under the supervision of an external examiner. External examiners should evaluate students by checking practical performance and conducting viva.
