Maharishi University of Information Technology, Lucknow

Course Curriculum for
B. Tech in Artificial Intelligence & Machine Learning

(Effective from the Session: 2025-26)

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

MAHARISHI SCHOOL OF ENGINEERING & TECHNOLOGY

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

First Semester

Sl. No.	Course category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BAML101	Problem Solving & Programming with Python	3-1-0	30	70	100	4
2	Core	BAML111	Problem Solving & Programming with Python Lab	0-0-4	20	30	50	2
3	Ability Based	BSHC101	Linear Algebra	3-1-0	30	70	100	4
4	Skill Based	AEC111	Communication Skill Lab	0-0-4	20	30	50	2
5	Core	BCSE102	Introduction to Computer Hardware	3-1-0	30	70	100	4
6	Core	BCSE112	Hardware Lab	0-0-4	20	30	50	2
7	Interdisciplinary	VAC101	Environmental Science	2-0-0	20	30	50	2
		TOTAL			**170**	**330**	**500**	**20**
1	Audit Course	AUD101	Basics of Transcendental Meditation and Yoga	2-0-0	20	30	50	0

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Second Semester

Sl. No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BAML201	Data Structures & Algorithms with Python	3-1-0	30	70	100	4
2	Core	BAML211	Data Structures & Algorithms with Python Lab	0-0-4	20	30	50	2
3	Ability Based	BSHC202	Probability & Statistics	3-1-0	30	70	100	4
4	Interdisciplinary	BSHC203	Engineering Physics	3-1-0	30	70	100	4
5	Interdisciplinary	BSHC213	Engineering Physics Lab	0-0-4	20	30	50	2
6	Interdisciplinary	BCEC211	Engineering Graphics & Design Lab	0-0-4	20	30	50	2
7	Value Added Course	VAC201	Indian Constitution	2-0-0	20	30	50	2
		TOTAL			**170**	**330**	**500**	**20**
1	Audit Course	AUD201	Increasing Coherence in Society by Maharishi's Knowledge	2-0-0	20	30	50	0

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Third Semester

Sl. No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BAML301	Algorithm Analysis and Design	3-1-0	30	70	100	4
2	Core	BAML302	AI-Driven Web Application Development	3-1-0	30	70	100	4
3	Minor	BAML303	Mastering Data Handling - SQL & No-SQL	3-1-0	30	70	100	4
4	Core	BAML304	Introduction to Machine Learning	3-1-0	30	70	100	4
5	Skill Based	BAML312	AI-Driven Web Application Development Lab	0-0-4	20	30	50	2
6	Skill Based	BAML313	Mastering Data Handling - SQL & No-SQL Lab	0-0-4	20	30	50	2
		TOTAL			**160**	**340**	**500**	**20**
1	Audit Course	AUD301	Qualities of Consciousness	2-0-0	20	30	50	0

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Fourth Semester

Sl.No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Minor	BCSE401	Cloud Computing	3-1-0	30	70	100	4
2	Core	BCSE402	Operating System	3-1-0	30	70	100	4
3	Core	BCSE403	Theory of Computation	3-1-0	30	70	100	4
4	Core	BAML404	Data Analysis & Visualization using Python	3-1-0	30	70	100	4
5	Core	BAML414	Data Analysis & Visualization using Python Lab	0-0-4	20	30	50	2
6	Skill Based	BCSE421	Seminar	0-0-4	50	-	50	2
7	Value Added Course	VAC401	Professional Ethics	2-0-0	20	30	50	2
		TOTAL			**210**	**340**	**550**	**22**
1	Audit Course	AUD401	Art of Living for fulfilment of Life	2-0-0	20	30	50	0

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Fifth Semester

Sl. No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BCSE501	Computer Networks	3-1-0	30	70	100	4
2	Core	BAML502	Machine Learning & AI: A Deep Dive	3-1-0	30	70	100	4
3	Core	BAML503	Software Engineering & DevOps	3-0-0	30	70	100	3
4	Core	BAML504	Optimization Techniques in Machine Learning	3-1-0	30	70	100	4
5	Open Elective	BEOE50*(1-4)	Open Elective-I	3-0-0	30	70	100	3
6	Skill Based	BECC511	Robotics Lab	0-0-4	20	30	50	2
7	Internship	BOOC515/BAML515	MOOC/Internship	0-0-4	50	-	50	2
		TOTAL			**220**	**380**	**600**	**22**

Open Elective - I (Theme: Business & Management)

1. BEOE501 - Principles of Management
2. BEOE502 - Organization Behaviour
3. BEOE503 - Business Intelligence
4. BEOE504 - Fintech Services

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Sixth Semester

Sl.No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BAML601	Applied Deep Learning	3-1-0	30	70	100	4
2	Minor	BAML602	Soft Computing	3-1-0	30	70	100	4
3	Minor	BAML603	Image Processing & Computer Vision	3-0-0	30	70	100	3
4	Core	BEPE60*(1-4)	Professional Elective - I	3-1-0	30	70	100	4
5	Minor	BEPE60*(5-8)	Professional Elective - II	3-0-0	30	70	100	3
6	Minor	BEOE60*(1-4)	Open Elective-II	2-0-0	20	30	50	2
7	Minor	BMAL614	Minor Project	0-0-4	20	30	50	2
		TOTAL			**190**	**410**	**600**	**22**

***Professional Elective - I (Theme: Data Science & Analytics)**

1. BEPE601 - Data Mining Techniques
2. BEPE602 - Introduction to Cognitive Science
3. BEPE603 - Big Data Analytics and Machine Learning
4. BEPE604 - AI in Internet of Things (IoT)

***Professional Elective - II (Theme: AI Foundations & Theoretical Approaches)**

1. BEPE605 - Deep Learning Architectures
2. BEPE606 - Explainable AI (XAI)
3. BEPE607 - AI Ethics and Governance
4. BEPE608 - Quantum Computing for AI

***Open Elective - II (Theme: Innovation & Entrepreneurship)**

1. BEOE601 - Innovation and Startup Management
2. BEOE602 - Innovation and Intellectual Property
3. BEOE603 - Design Thinking for Engineers
4. BEOE604 - Sustainable Technology & Development

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Seventh Semester

Sl.No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Core	BAML701	Natural Language Processing	3-1-0	30	70	100	4
2	Minor	BAML702	AI Model Deployment, MLOps & Industry Applications	3-1-0	30	70	100	4
3	Core	BEPE70*(1-4)	Professional Elective - III	3-0-0	30	70	100	3
4	Minor	BEPE70*(5-8)	Professional Elective - IV	3-0-0	30	70	100	3
5	Value Added	BCSE721	Industrial Interaction	0-0-4	50	-	50	2
6	Core	BAML712	Capstone Project	0-0-12	50	100	150	6
		TOTAL			**220**	**380**	**600**	**22**

***Professional Elective - III (Theme: Advanced AI Applications)**

1. BEPE701 - Generative AI
2. BEPE702 - Reinforcement Learning
3. BEPE703 - Multi-Agent Systems
4. BEPE704 - Blockchain and AI & ML

***Professional Elective - IV (Theme: Emerging AI Technologies)**

1. BEPE705 - AI Driven Edge Computing
2. BEPE706 - Human-AI Interaction
3. BEPE707 - Tiny ML
4. BEPE708 - Federated Learning

Evaluation Scheme

B. Tech in Artificial Intelligence & Machine Learning

Eighth Semester

Sl.No.	Course Category	Course Code	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Dissertation	BAML821	Major Project	0-0-44	200	400	600	22
		TOTAL			**200**	**400**	**600**	**22**

Semester I

Detailed First Year Curriculum Contents

Course Code	BAML101				
Category	Core				
Course title	Problem Solving & Programming with Python				
Scheme & Credits	L	T	P	Credits	Semester I
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand basic concepts of Python programming and implement Python scripts using fundamentals.
2. Master data structures in Python (lists, tuples, dictionaries, sets) and their applications.
3. Apply object-oriented programming principles to build classes, methods, and inheritances.
4. Implement file handling techniques, create and use modules/packages, and implement exceptions.
5. Use Streamlit to create interactive applications by integrating data analysis and visualization.

Unit I: Python Fundamentals

Introduction to Python: History, features, and installation, Basic Syntax: Variables, data types (integers, floats, strings, booleans), operators, input/output, Control Flow: Conditional statements (if, elif, else), loops (for, while), break and continue statements. Functions: Defining and calling functions, parameters, return values, scope. Basic coding exercises: Implementing basic algorithms using fundamentals. Practice: Coding challenges.

Unit II: Data Structures in Python

Lists: Creation, indexing, slicing, methods, list comprehensions. Tuples: Creation, immutability, tuple packing and unpacking, Dictionaries: Creation, access, modification, dictionary methods. Sets: Creation, set operations, methods, Understanding mutability and immutability, Practice: Problems on different data structures

Unit III: Object-Oriented Programming in Python

Introduction to OOP: Classes, objects, attributes, methods, encapsulation., Inheritance: Single, multiple, and multilevel inheritance, method overriding. Polymorphism: Method overloading, duck typing., Abstraction and Encapsulation. Creating and implementing modules, and packages., Practice: Implementing OOP concepts in different problems.

Unit IV: File Handling and Modules

File Handling: Reading, writing, appending, file modes, handling exceptions., Working with different file formats (CSV, JSON)., Modules and Packages: Creating, importing, and using modules, installing packages using pip., Exception Handling: try, except, finally blocks., Practice: Building a practical utility with all the above.

Unit V: Building Interactive Applications with Streamlit and Data Analysis

Introduction to Streamlit: Installation, basic components, creating interactive apps., Building Data Visualization Apps with Streamlit., Introduction to Data Analysis with Python (Pandas)., Data manipulation and analysis with Pandas., Data Visualization with Matplotlib/Seaborn., Integrating Pandas data frames and data visualization charts to Streamlit apps., Practice: Mini-project with Streamlit and data analysis.

Textbooks:

1. Fluent Python Luciano Ramalho, O'Reilly Media, 2nd, 2021
2. Python Cookbook, David Beazley and Brian K. Jones, O'Reilly Media,3rd,2013

Reference Books:

1. Python Crash Course, Eric Matthes No Starch Press, 2nd, 2019
2. Automate the Boring Stuff with Python, Al Swigart Starch Press,2nd,2019

Course Code	BSHC101				
Category	Ability Based				
Course title	Linear Algebra				
Scheme & Credits	L	T	P	Credits	Semester 1
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes:

1. To apply differential and integral calculus to notions of curvature and to improper integrals.
2. To understand the basics of Beta and Gamma functions
3. The essential tools of matrices and linear algebra including linear transformations, eigenvalues, diagonalization and orthogonalization
4. Solve higher order ordinary differential equations.
5. Evaluate the total derivative of a function, expand the given function as series and locate the maximum and minimum for multivariate function.

Unit 1: Introduction

Evolutes & involutes, Evaluation of definite and improper integrals, Beta & Gamma functions and their properties, Applications of definite integrals to evaluate surface areas and volumes of revolutions

Unit 2: Calculus

Rolle's theorem, Mean Value Theorem, Taylor's and Maclaurin theorems with remainders, Indeterminate forms and L'Hospital's rule, Maxima & minima

Unit 3: Matrices

Matrices, vectors: addition and scalar multiplication, matrix multiplication, Linear systems of equations, linear independence, rank of matrix, determinants, Cramer's rule, inverse of matrix, Gauss elimination and Gauss-Jordan elimination

Unit 4: Introduction to Vector spaces

Vector space, linear dependence of vectors, basis, dimension. Linear transformations (maps), range and kernel of a linear map, Rank and nullity, Inverse of a linear transformation, rank-nullity theorem, Composition of linear maps, Matrix associated with a linear map

Unit 5: Vector spaces

Eigen values, Eigen vectors, symmetric, skew symmetric and orthogonal Matrices, Eigen base, Diagonalization, Inner product spaces, Gram-Schmidt orthogonalization

Textbooks:

1. Ramana B.V., Higher Engineering Mathematics
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics
3. B.S. Grewal, Higher Engineering Mathematics
4. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An Introduction to Linear Algebra

Reference Books:

1. A.R. Vasishtha and J.N. Sharma, Linear Algebra
2. Kenneth Hoffman and Ray Kunze, Linear Algebra (second edition)
3. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry
4. Erwin Kreyszig, Advanced Engineering Mathematics
5. D. Poole, Linear Algebra: A Modern Introduction
6. Veeraranjan T., Engineering Mathematics for first year

Course Code	BCSE102				
Category	Core				
Course title	Introduction to Computer Hardware				
Scheme & Credits	L	T	P	Credits	Semester I
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcomes:

1. To understand and classify different computer systems
2. To describe different types of peripherals
3. To understand types of software
4. To describe various types of storage devices and their storage capacities.
5. To describe operating system

Unit 1: Introduction

Introduction of Computer, Evolution & Classification of computers, Applications, advantages & disadvantages of computers, Computer system and its components.

Unit 2: Hardware & Software

Input devices, Output devices, Classification of Software, Programming Languages, Program development process.

Unit 3: Memory System

Introduction to storage devices & memory system, Primary Storage, Secondary storage.

Unit 4: Number Systems

Introduction to Number systems, Non positional number system, Positional number system, Conversion, Shortcut methods.

Unit 5: Operating Systems

Introduction & definition of operating systems, Computer Processing Techniques, Batch processing, Multiprogramming, Multiprocessing, Time-sharing, On-line processing, Real Time processing.

Textbooks:

1. Rajaraman, **V.,** Fundamentals of Computers, 6th Edition, PHI Learning.
2. P.K. Sinha and Priti Sinha, Computer Fundamentals, BPB Publications.

Reference Books:

1. Randal E. Bryant and David R. O'Hallaron, Computer Systems: A Programmer's Perspective, Third Edition, Pearson, 2016
2. P K Sinha, Computer Fundamentals: Concepts, Systems & Applications – 8th Edition

Course Code	VAC101				
Category	Interdisciplinary				
Course title	Environmental Science				
Scheme & Credits	L	T	P	Credits	Semester I
	2	0	0	2	
Pre-requisite (if any)	None				

Course outcomes:

1. This course is expected to inculcate a critical thinking on various dimensions of environment through knowledge, skill, critical thinking and problem-solving.
2. Gain knowledge about environment and ecosystem
3. Students will learn about natural resource, its importance and environmental impacts of human activities on natural resource
4. Gain knowledge about the conservation of biodiversity and its importance

Unit 1: Understanding the Environment

Environment: concept, importance and components, Ecosystem: Concept, structure and function (food chain, food web, ecological pyramids and energy flow), Ecosystem services: (Provisioning, regulating and cultural), Biodiversity: levels, values and threats and conservation, Concept and objectives of environmental education, environmental ethics.

Unit 2: Natural resources and Environmental pollution

Natural resources: Renewable and non-renewable (Global status, distribution and production), Management of natural resources: Individual, community and government managed, Air, water and soil pollution: Causes, consequences and control.

Unit 3: Solid waste management and Climate change

Solid waste management: Collection, segregation, transportation and disposal; 3R's, Climate change: Causes and consequences

Textbooks:

1. **Erach Bharucha**, *Environmental Studies for Undergraduate Courses*, University Grants Commission, University Press (India) Pvt. Ltd.
2. **R. Rajagopalan**, *Environmental Studies: From Crisis to Cure*, 3rd Edition, Oxford University Press.

Reference Books:

1. Asthana, D. K. Text Book of Environmental Studies. S. Chand Publishing.
2. Basu, M., Xavier, S. Fundamentals of Environmental Studies, Cambridge University Press, India.
3. Basu, R. N., (Ed.) Environment. University of Calcutta, Kolkata.
4. Bharucha, E. Textbook of Environmental Studies for Undergraduate Courses. Universities Press.
5. Miller T.O. Jr., Environmental Science, Wadsworth Publishing Co.
6. Wagner K.D. Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p.
7. Mckinncv, M.L. &Schoch. R.M. Environmental Science systems & Solutions. Web enhanced edition.

Course Code	BAML111				
Category	Core				
Course title	Problem Solving & Programming with Python Lab				
Scheme & Credits	L	T	P	Credits	Semester 1
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes:

1. Demonstrate the use of Python fundamentals such as variables, control flow, functions, and file handling.
2. Apply object-oriented programming concepts including classes, objects, inheritance, encapsulation, and polymorphism.
3. Build interactive web applications using Streamlit integrated with data analysis and visualization libraries.
4. Implement exception handling, modular programming, and package management in Python-based projects.
5. Deploy Python-based applications (CLI or web) with complete documentation, user interface, and functional features.

List of Experiments:

1. **Project Title:** Command-Line Application using Python and OOP
Project Objective:
Develop a command-line application that solves a practical problem and demonstrates understanding of core Python concepts and object-oriented programming (OOP).
Project Outcome:
Demonstrate implementation of all the basic concepts of Python with proper code documentation.

2**. Project Title:** Interactive Web/Data Analysis Application using Streamlit
Project Objective:
Develop an interactive web application or data analysis project using Streamlit, with full implementation and local deployment.

3. **Project Title:** Personal Portfolio Website with GitHub Pages
Project Objective:
Git & GitHub basics for version control, introduced mini AI API exercises (e.g., calling OpenAI GPT APIs) for early exposure.

Project Outcome:
Demonstrate proficiency in using Python libraries and frameworks via a live data analysis app.

Course Code	AEC111				
Category	Skill Based				
Course title	Communication Skill Lab				
Scheme & Credits	L	T	P	Credits	Semester I
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes:

1. Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others.
2. Understand and practice different techniques of communication.
3. Practice and adhere to the 7Cs of Communication
4. Familiarize with different types of Communication
5. Understand and practice Interview Etiquettes.

Exercise 1: Reading Skills

Reading Tactics and strategies, reading purposes–kinds of purposes and associated comprehension, reading for direct meanings, reading for understanding concepts, details, coherence, logical progression and meanings of phrases/ expressions.

Exercise 2: Writing Skills

Guidelines for effective writing, Writing styles for application, personal letter, official/ business letter, Resume, memo, notices. Outline and revision.

Exercise 3: Listening and Speaking Skills

Barriers to listening, Effective listening skills, Feedback skills, Activities: Listening exercises – Listening to conversation, News and TV reports, Components of a meaningful and easy conversation, Understanding the cue and making appropriate responses, Forms of polite speech; asking and providing information on general topics. The Common Errors in English module is intended to help users avoid the common mistakes made in the use of the English language. These include, among others, errors made in the following: (https://ve-iitg.vlabs.ac.in/Common%20Error.html)
a. Word order, b. Spelling, c. Confused words, d. Tautology, e. Omissions, f. Tense, g. Subject-verb agreement, h. Prepositions, Technical communication is a method that involves the generation of information and data about technical processes or products intended for a particular audience. Technical writing, which is a form of technical communication, is a style of writing which enables readers to understand a process or concept. It requires having a clear understanding of the purpose of the product to be created and knowledge about its audience.(https://ve-iitg.vlabs.ac.in/Technical%20Communication.html)

Exercise 4: Integrated Skills for Critical Thinking, Problem Solving, and Scientific Communication in AI

This module focuses on enhancing students' abilities in critical thinking, analytical reasoning, and structured problem-solving through interactive workshops and collaborative tasks. It also develops scientific writing and communication skills essential for AI research and interdisciplinary collaboration.

Textbooks:

1. **M. Ashraf Rizvi**, *Effective Technical Communication*, McGraw Hill Education.
2. **Meenakshi Raman and Sangeeta Sharma**, *Technical Communication: Principles and Practice*, 3rd Edition, Oxford University Press.

Reference Books:

1. Oxford Guide to Effective Writing and Speaking by John Seely.
2. English Grammar in Use (Fourth Edition) by Raymond Murphy, CUP

Course Code	BCSE112				
Category	Core				
Course title	Hardware Lab				
Scheme & Credits	L	T	P	Credits	Semester I
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes:

1. To understand and classify different computer systems
2. To describe different types of peripherals
3. To understand types of software
4. To describe various types of storage devices and their storage capacities.
5. To describe operating system

List of Experiments:

1. Front panel indicators & switches and Front side & rear side Connectors.
2. Familiarize the computer system Layout: Marking positions of SMPS, Motherboard, FDD, HDD, CD, DVD and add on cards.
3. Configure BIOS setup program and troubleshoot the typical problems using BIOS utility.
4. Install Hard Disk and configure to the Pc's
5. Install and Configure a DVD Writer and a Blu-ray Disc writer and recording DVD and Blu-ray disk.
6. Printer Installation and Servicing and troubleshoot
7. Install and configure Scanner, Web cam, Cell phone and bio-metric device with system and troubleshoot the problems
8. Assemble a system with add on cards and check the working condition of the system and install OS.
9. Install and Configure Dual OS Installation
10. Assembling and Disassembling of Laptop to identify the parts and to install OS and configure it.
11. To learn about the representation of signed and unsigned integers. Also using 2's complement representation of numbers for performing arithmetic over other representations. (https://cse11-iiith.vlabs.ac.in/exp/integers-arithmetic/objective.html)
12. To learn the fundamentals of Floating Point Representation of Numbers.(https://cse11-iiith.vlabs.ac.in/exp/floating-point-numbers/objective.html)

Reference Books

1. Randal E. Bryant and David R. O'Hallaron, Computer Systems: A Programmer's Perspective, Third Edition, Pearson, 2016
2. P K Sinha, Computer Fundamentals: Concepts, Systems & Applications – 8th Edition

SYLLABUS OF SUBJECT SCIENCE OF CONSCIOUSNESS

Course Code	AUD101				
Category	Audit Course				
Course title	Basics of Transcendental Meditation and Yoga				
Scheme & Credits	L	T	P	Credits	Semester I
	2	0	0	0	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Define the concepts and principles of Transcendental Meditation (TM) and Yoga.
2. Recognize the role of Yoga as a holistic approach to achieving mental, physical, and spiritual well-being.
3. Analyze and reflect on how practicing Yoga and TM aligns individual life with natural and environmental harmony.

Unit – I: Science of Consciousness and Transcendental Meditation
Introduction to Science of Consciousness and its practical aspect, Concept of Knower, Known, Object of Knowing, Introduction to Transcendental Meditation, Scientific Research on Transcendental Meditation, How Transcendental Meditation differs from other forms of meditation, Introducing CBE - Transcendental Meditation around the world, Preparation to start learning Transcendental Meditation

Unit – II: Learning Transcendental Meditation
Preparation to learn Transcendental Meditation, Personal Instruction, Supplying Practical Understanding of Correct Meditation, Effects of Transcendental Meditation on Mind and Body, Development of Higher States of Consciousness

Unit – III: Consciousness-based Education (CBE)
Introduction to Consciousness-based Education, CBE around the world and in India

Semester II

Detailed First Year Curriculum Contents

Course Code	BAML201				
Category	Core				
Course title	Data Structures & Algorithms with Python				
Scheme & Credits	L	T	P	Credits	Semester II
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcomes:

1. Understand algorithmic thinking and complexity concepts.
2. Develop Python programs using iterative and recursive logic.
3. Implement and use data structures like lists, stacks, queues, and trees.
4. Analyze algorithm efficiency and optimize problem-solving.
5. Design and develop small-scale projects using structured problem-solving.

Unit 1: Algorithmic Thinking and Complexity
What is an algorithm? Characteristics and examples, types of algorithms (brute force, greedy, recursive, divide and conquer), introduction to Big-O notation, time and space complexity with examples, designing pseudocode and estimating complexity. Translating algorithms into executable Python code, recursion in problem solving (factorial, towers of Hanoi, search), algorithm tracing and debugging techniques, modular programming and reusable components, implementing algorithms using recursive and modular structures.

Unit 2: Linear Data Structures and Searching/Sorting
Introduction to linear data structures in Python, use of lists for dynamic data storage and manipulation, searching and sorting algorithms (linear, binary, bubble, insertion, merge), string manipulation and pattern matching, problems on list transformations and string parsing.

Unit 3: Stack, Queue, and Linked List
Stack implementation and applications (e.g., expression evaluation), queue types (simple, circular, deque), singly linked list (nodes, traversal, insertion, deletion), hands-on with list-based and class-based implementations, use-case problems like browser history and task scheduling.

Unit 4: Trees and Recursion-Based Problem Solving
Introduction to trees, binary trees, and traversals (inorder, preorder, postorder), recursion in tree operations, problem-solving using recursion (factorial, Fibonacci, subset generation), recursive functions and tree-based challenges.

Unit 5: AI-Relevant Algorithms and Complexity Analysis
Introduction to Graph, search algorithms (BFS, DFS, A*), graph algorithms (shortest paths, MST), greedy and dynamic programming methods, optimization techniques (hill climbing, simulated annealing), constraint satisfaction problems, basic linear programming, NP-completeness, and performance evaluation of AI-relevant algorithms.

Text Book(s):
1. Python Programming: An Introduction to Computer Science – John Zelle
2. Problem Solving with Algorithms and Data Structures Using Python – Miller & Ranum
3. Introduction to Algorithms – Cormen et al.

Course Code	BSHC202				
Category	Ability Based				
Course title	Probability & Statistics				
Scheme & Credits	L	T	P	Credits	Semester II
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes:

1. Compute numerical quantities that measure the central tendency and dispersion of a set of data.
2. Understand basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with common named discrete and continuous random variables.
3. Apply general properties of the expectation and variance operators.
4. Understand the properties and fitting of the Bernoulli, Binomial and Poisson distribution.
5. To tabulate statistical information given in descriptive form

Unit 1: Introduction
Meaning & scope of statistics, Frequency distribution & measures of central tendency, Arithmetic mean, median & mode

Unit 2: Measures of Dispersion
Dispersion & measures of dispersion, Range, Quartile deviation, mean deviation & root mean square deviation, Variance & standard deviation

Unit 3: Probability
Introduction to probability, Mathematical & statistical probability, Mathematical tools (Algebra of sets), Axiomatic approach to probability, random experiment, Laws of addition & multiplication of probability, Conditional probability, independent events & Baye's theorem.

Unit 4: Random Variables and Distribution Functions (7 Hrs.)
Random Variable, Distribution Function & Properties of Distribution Function, Discrete Random Variable, Probability Mass Function & Discrete Distribution Function, Continuous Random Variable & Probability Density Function, Various Measures of Central Tendency, Dispersion, Skewness and Kurtosis for Continuous Distribution.

Unit 5: Theoretical Discrete Distributions
Bernoulli distribution, Binomial Distribution and Poisson Distribution

Textbooks:

1. **S.C. Gupta and V.K. Kapoor**, *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons.
2. **Sheldon Ross**, *Introduction to Probability and Statistics for Engineers and Scientists*, 5th Edition, Academic Press.

Reference Books

1. Fundamentals of Mathematical Statistics, S.C. Gupta & V.K. Kapoor (S. Chand & Sons)
2. Higher Engineering mathematics, Dr B.S. Grewal (Khanna publishers)
3. Probability and statistics for engineers and scientists, Sheldon M. Ross(Academic Press)
4. Operations research, S.D. Sharma
5. Mathematics for engineers, K.B. Dutta and M.S.Sriniva (Cengage publications)
6. Probability and statistics, TKV Iyengar

Course Code	BSHC203				
Category	Interdisciplinary				
Course title	Engineering Physics				
Scheme & Credits	L	T	P	Credits	Semester II
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcomes:

1. To understand relativistic mechanics
2. To describe electromagnetic field theory
3. To understand quantum mechanics
4. To describe various phenomenon of wave optics
5. To understand fiber optics and laser

Unit 1: Relativistic Mechanics

Frame of reference, Inertial & non-inertial frames, Galilean transformations, Michelson-Morley experiment, Postulates of special theory of relativity, Lorentz transformations, Length contraction, Time dilation, Velocity addition theorem, Variation of mass with velocity, Einsteins mass energy relation, Relativistic relation between energy and momentum, Massless particle.

Unit 2: Electromagnetic Field Theory

Continuity equation for current density, Displacement current, modifying equation for the curl of magnetic field to satisfy continuity equation, Maxwells equations in vacuum and in non-conducting medium, Energy in an electromagnetic field, Poynting vector and Poynting theorem, Plane electromagnetic waves in vacuum and their transverse nature. Relation between electric and magnetic fields of an electromagnetic wave, Energy and momentum carried by electromagnetic waves, Resultant pressure, SMin depth.

Unit 3: Quantum Mechanics

Black body radiation, Stefan's law, Wien's law, Rayleigh-Jeans law and Planc's law, Wave particle duality, Matter waves, Time-dependent and time-independent Schrodinger wave equation, Born interpretation of wave function, Solution to stationary state Schrodinger wave equation for one-Dimensional particle in a box, Compton effect

Unit 4: Wave Optics

Coherent sources, Interference in uniform and wedge-shaped thin films, Necessity of extended sources, Newton's Rings and its applications. Fraunhoffer diffraction at single slit and at double slit, absent spectra, Diffraction grating, Spectra with grating, Dispersive power, resolving power of grating, Rayleigh's criterion of resolution, Resolving power of grating.

Unit 5: Fibre Optics & Laser

Fibre Optics**:** Introduction to fibre optics, Acceptance angle, Numerical aperture, Normalized frequency, Classification of fibre, Attenuation and Dispersion in optical fibres. Laser: Absorption of radiation, Spontaneous and stimulated emission of radiation, Einstein's coefficients, Population inversion, Various levels of Laser, Ruby Laser, He-Ne Laser, Laser applications.

Textbooks:

1. **Arthur Beiser**, *Concepts of Modern Physics*, 6th Edition, McGraw Hill Education.
2. **Gaur and Gupta**, *Engineering Physics*, Dhanpat Rai Publications.

Reference Books

1. Concepts of Modern Physics – AurthurBeiser (Mc-Graw Hill)
2. Introduction to Special Theory of Relativity- Robert Resnick (Wiley)
3. Optics - Brijlal& Subramanian (S. Chand)
4. Engineering Physics-Malik HM and Singh AM (McGrawHill)
5. Practical Physics- M. M. Dey& B. N. Dutta (Kalyani Publishers New Delhi)
6. Engineering Physics-Theory and Practical- Katiyar&Pandey (Wiley India)
7. Engineering Physics Practical- S M Gupta (KrishnaPrakashan Meerut)
8. Engineering Physics: Theory and Practical- Matiyar and Pandey (Wiley India)
9. Applied Physics for Engineers- Neeraj Mehta (PHI Learning, New)

Course Code	VAC201				
Category	Value Added				
Course title	Indian Constitution				
Scheme & Credits	L	T	P	Credits	Semester II
	2	0	0	2	
Pre-requisite (if any)	None				

Course outcomes:

1. The students will learn to facilitate the students with the concepts of Indian Constitution and to make them understand its Importance.
2. To facilitate the students with the concepts of Indian Constitution and its importance.
3. To provide a deep understanding of the multi-level governance system to, enable students to critically analyze political processes.
4. To facilitate with a comprehensive understanding of the role, functions, and significance of the Election Commission of India (ECI) in ensuring free, fair, and democratic elections in the country.

Unit 1: Introduction

Constitution meaning of the term, Indian Constitution: Sources and Constitutional History, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy

Unit 2: Union Government, State Government and Local administration

Structure of the Indian Union: Federalism, Centre- State relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha: Role and Position, CM and Council of ministers, State Secretariat: Organisation, Structure and Functions, Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role, Block level: Organizational Hierarchy, Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit 3: Election Commission

Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Text Books

1. 'Indian Administration' by SubhashKashyap
2. 'Indian Constitution' by D.D. Basu
3. 'Indian Administration' by Avasti and Avasti

Reference Books:

1. M. Laxmikanth, Indian Polity, 6th Edition, McGraw Hill Education.
2. D.D. Basu, Introduction to the Constitution of India, LexisNexis.

Course Code	BAML211				
Category	Core				
Course title	Data Structures & Algorithms with Python Lab				
Scheme & Credits	L	T	P	Credits	Semester II
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes:

1. Understand and implement core algorithmic logic with performance evaluation.
2. Apply various data structures effectively for structured data manipulation.
3. Solve real-world problems using recursion, searching, and sorting techniques.
4. Design efficient solutions using stack, queue, and linked list implementations.
5. Build modular and reusable Python code to simulate data management systems.

List of Experiments

1. Project Title: Algorithmic Problem Solving
Project Objective: Solve real-life problems like sorting records, searching contact lists, etc., using Python algorithms.
Project Outcome: Understand and implement core algorithmic logic with performance evaluation.

2. Project Title: Student Management System / Task Tracker
Project Objective: Build a mini student management system or task tracker using custom data structures.
Project Outcome: Apply various data structures effectively for structured data manipulation.

3. **Project Title: Campus Navigation and Emergency Response System**
Project Objective: Design and implement a system that models a university campus using graphs to find the shortest or optimal path between buildings or locations. Use priority queues to simulate an emergency response system where incidents are prioritized and assigned to responders based on severity and proximity.
Project Outcome: Apply **graph algorithms** (like Dijkstra's or BFS/DFS) in real-world scenarios and Implement and use **priority queues** to manage tasks by urgency.

Course Code	BSHC213				
Category	Interdisciplinary				
Course title	Engineering Physics Lab				
Scheme & Credits	L	T	P	Credits	Semester II
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes:

1. The student will learn to solve the classical and wave mechanics problems
2. To develop the understanding of laws of thermodynamics and their application invarious processes
3. To formulate and solve the engineering problems on Electromagnetism &
4. Electromagnetic Field Theory,
5. To be aware of limits of classical physics,
6. To apply the ideas in solving the problems in their parent streams

List of Experiments:

1. To determine the value of acceleration due to gravity by mean of bar pendulum (Compound pendulum).
2. To determine surface tension of liquid (water) by capillary rise method.
3. To determine the Young's modulus of elasticity for the material of a beam by the method of bending.
4. To determine the A.C. mains frequency of given electromagnet using sonometer unit.
5. To determine the energy band gap of a given semi-conductor material.
6. To determine the specific rotation the cane sugar solution by using quartz polarimeter.
7. To study and determine the wavelength of monochromatic light using Newton's Rings.
8. To determine the refractive index of the glass prism surface using Brewster's Law.
9. To Determine Energy Band Gap of Semiconductor (https://bop-iitk.vlabs.ac.in/exp/energy-band-gap/index.html)
10. To find Viscosity of Liquid (https://bop-iitk.vlabs.ac.in/exp/liquid-viscosity)

Reference Books:

1. Engineering Physics: Theory and Practical- Matiyar and Pandey, Wiley India
2. Applied Physics for Engineers- Neeraj Mehta. PHI Learning
3. Engineering Physics Malik HM and Singh AM McGraw-Hill
4. Practical Physics- M. M. Dey & B. N. Dutta, Kalyani Publishers New Delhi

Course Code	BCEC211				
Category	Interdisciplinary				
Course title	Engineering Graphics & Design Lab				
Scheme & Credits	L	T	P	Credits	Semester II
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes: The student will learn:

1. Introduction to Engineering design and its place in society
2. Exposure to the visual aspects of engineering design
3. Exposure to engineering graphics standards
4. Exposure to solid modelling
5. Exposure to computer-aided geometric design
6. Exposure to creating working drawings
7. Exposure to engineering communication

List of Experiments:

1. Practice sheet (which includes dimensioning methods, different types of line, construction of different polygon, divide the line and angle in parts, use of stencil)
2. Plane scale and diagonal scale.
3. Loci of points: Path of the points moving on Simple mechanisms.
4. Engineering curves: Construction of Conics, Cycloidal Curves, Involutes and Spirals along with normal and tangent to each curve.
5. Projection of line: Projections of the points located in same quadrant and different quadrants, Projections of line with its inclination to one reference plane and with two reference planes.
6. Projection of plane: Projections of planes (polygons, circle and ellipse) with its inclination to one reference plane and with two reference planes.
7. Projection of solid, section of solid and development of surfaces: Projections of solids (Cylinder, Cone, Pyramid and Prism) along with frustum with its inclination to one reference plane and with two reference planes.
8. Orthographic projection: Projections from the pictorial view of the object on the principal planes for view from front, top and sides using first angle projection method and third angle projection method.
9. Isometric projection: Conversion of orthographic views into isometric projection, isometric view or drawing of simple objects.
10. At least one orthographic drawing (three views) using Line, Circle, Polyline, Rectangle,Hatch, Fillet, Chamfer, Trim, Extend, Offset, Dim style, etc AutoCAD commands.
11. To develop an understanding of stress-strain curves of materials, and learn how to use them to determine various mechanical properties of ductile and brittle materials. (https://eerc01-iiith.vlabs.ac.in/exp/tensile-test-experiment/objective.html)
12. To find the angle of twist and to obtain some of the mechanical properties of the given material by conducting torsion test. (https://eerc01-iiith.vlabs.ac.in/exp/torsion-test-experiment/objective.html)

Reference Books

1. Bhatt N.D., Panchal V.M. & Ingle P.R.
2. Shah, M.B. &Rana B.C., Engineering Drawing & Computer Graphics
3. Agrawal B. &Agrawal C.M., Engineering Graphics
4. Narayana, K.L. & P Kannaiah, Text book on Engineering Drawing

Course Code	AUD201				
Category	Audit Course				
Course title	Increasing Coherence in Society by Maharishi's Knowledge				
Scheme & Credits	L	T	P	Credits	Semester II
	2	0	0	0	
Pre-requisite (if any)	None				

Course Outcomes:

1. Deepened Understanding of Maharishi's Teachings: Participants will emerge from the course with a deepened understanding of Maharishi Mahesh Yogi's teachings and their relevance in promoting positivity, coherence, and peace in society.

2. Enhanced Meditation Practice: Students will enhance their meditation practice through advanced lectures, follow-up sessions, and personal checking's, leading to greater proficiency in Transcendental Meditation and increased personal well-being.

3. Inspiration for Personal Growth: The course will inspire participants to embark on a journey of personal growth and self-awareness, drawing inspiration from Maharishi's life and teachings to cultivate positivity, resilience, and inner peace.

Unit – I: Increasing Positivity & Coherence in the Society I

Introduction to Maharishi Effect, Maharishi Effect draws parallels with Modern Science, Maharishi Effect verified by Scientific Research

Unit – II: Maharishi in the World

Who is Maharishi Mahesh Yogi, Narratives from Maharishi's Life, Timeline of the Achievements, Contribution in the revival of Vedic Knowledge, Maharishi's World Plan

Unit – III: Maharishi Yoga Asanas

Introduction to Maharishi Yoga Asanas, Practice Yoga Asanas that promote integration of mind and body, Learn about the influence and benefits of each posture on your physiology

Text Book (s):

1. Gilpin Geoff. (2006). The Maharishi Effect: A Personal Journey through the Movement That Transformed American Spirituality. Penguin Group (USA), Tarcher Perigee
2. Aron Elaine &Aron Arthur. (1986). The Maharishi Effect: A Revolution Through Meditation. SailPoint Publishing, New Hampshire. E P Dutton.

References:

1. Halley Susi (2019, March 25). The Maharishi Effect as a Solution to the problem of antisemitism in America from https://www.researchgate.net/publication/333356375
2. Orme-Johnson, D. W., & Fergusson, L. (2018). Global impact of the Maharishi Effect from 1974 to 2017: Theory and research. Journal of Maharishi Vedic Research Institute

Semester III

Detailed Second Year Curriculum Contents

Course Code	BAML301				
Category	Core				
Course title	Algorithm Analysis and Design				
Scheme & Credits	L	T	P	Credits	Semester
	3	1	0	4	III
Pre-requisite (if any)	None				

Course Outcome:

1. Describe asymptotic analysis concepts and use them to evaluate the time-complexity of different algorithms.
2. Explain, apply and analyze the divide and conquer, greedy method and dynamic programming techniques to solve various engineering problems.
3. Discuss and use Branch and Bound, and pattern-matching algorithms.
4. Discuss randomized algorithms for min-cut and 2-SAT problem.
5. Understand the concepts of NP-Hard and NP-Complete problems.

Unit 1: Introduction

Asymptotic notations for time and space complexity, including Big-Oh notation, Θ notation, Ω notation, the little-oh notation, and the little-omega notation. Recurrence relations: iteration method, recursion tree method, substitution method, master method (with proof), subtract and conquer master method (with proof). Data structures for disjoint sets, medians, and order statistics. Complexity analysis and sorting algorithms including insertion sort, merge sort, and quick sort. Strassen's algorithm for matrix multiplications.

Unit 2: Dynamic Programming

Ingredients of dynamic programming with emphasis on optimal substructure, overlapping substructures, and memorization. Problems such as matrix chain multiplication, longest common subsequence, optimal binary search trees, and 0-1 knapsack problem. Computation of binomial coefficients through dynamic programming and the Floyd-Warshall algorithm.

Unit 3: Greedy Algorithm

Elements of greedy strategy, overview of local and global optima, and matroid theory. Applications to activity selection problem, fractional knapsack problem, Huffman codes, and a task scheduling problem. Algorithms for minimum spanning trees including Kruskal's and Prim's algorithm. Single source shortest path algorithms: Dijkstra's and Bellman-Ford algorithms, including proofs of correctness.

Unit 4: String Matching

String matching algorithms including the naïve string matching algorithm, Rabin-Karp algorithm, string matching with finite automata, and the Knuth-Morris-Pratt (KMP) algorithm.

Unit 5: NP-Problem

NP-complete problems, polynomial-time verification, NP-completeness and reducibility, proofs of NP-completeness, and NP-hard problems. Case studies of NP-complete problems including the vertex cover problem and clique problem.

Text Book (s):

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, Clifford Stein, "Introduction to Algorithms", 3rd Ed., PHI, 2013.
2. Jon Klenberg,EvaTardos,"Algorithm Design", Pearson Publications,2014

References:

1. Sara Basse, "introduction to Design &analysis",Pearson
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Computer Algorithms/C++ "Second Edition, Universities Press.
3. A. V. Aho, J. E. Hopcroft, J. D. Ullman, "The Design and Analysis of Computer Algorithms", Pearson Publication, 2013.
4. Richard Neapolitan, "Foundations of Algorithms" , Fifth Edition, Jones & Bartlett Learning

Course Code	BAML302				
Category	Core				
Course title	AI-Driven Web Application Development				
Scheme & Credits	L	T	P	Credits	Semester III
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes:

1. Understand the architecture and components of AI-driven web applications.
2. Design responsive and user-friendly front-end interfaces using modern frameworks.
3. Implement server-side logic and integrate databases for dynamic content.
4. Apply machine learning models within web applications using appropriate tools.
5. Deploy and maintain scalable AI-enabled web solutions on cloud platforms.

Unit 1: Introduction to AI-Driven Web Applications
The evolution from traditional web applications to AI-driven systems. The key components of full-stack intelligent applications including client-side, server-side, and AI layers. Web architecture, data flow, role of APIs, and how AI enhances functionality through automation and personalization. Real-world examples such as chatbots, recommendation engines, and predictive tools. Ethical issues, privacy considerations, and current trends in AI-enabled web development. The foundation for understanding how machine learning integrates with modern web technologies to create dynamic, data-driven user experiences.

Unit 2: Front-End Technologies and UX
Building engaging and responsive front-end interfaces. HTML5, CSS3, JavaScript (ES6+), and modern UI frameworks like React or Angular. Design principles, intuitive layouts, and cross-platform compatibility. Placed on accessibility, usability, and interaction design. Front-end communication with AI services and dynamic content rendering. Develop visually appealing and functional front ends integrated with intelligent features.

Unit 3: Back-End Development
Server-side programming essential for handling logic, data, and communication with front-end clients. Technologies such as Node.js or Python (Flask/Django), RESTful API development and database interaction using SQL and NoSQL. Authentication, authorization, session handling, and middleware configuration. Real-time data handling, asynchronous operations, and integration with AI services are explored. Creating secure and scalable server architectures that support intelligent processing. Students will gain hands-on experience in building complete backend systems that serve data and AI functionality efficiently to the front-end layer.

Unit 4: AI Integration in Web Apps
AI and machine learning capabilities into web applications. TensorFlow.js and ML5.js to run models in-browser and on the server. Natural language processing for chatbots, recommendation systems, and image/audio classification Input data, connect trained models, and interpret output within a web interface. Ethical AI use, model limitations, and user transparency. decision-making in web platforms, usability, and fairness.

Unit 5: Deployment, Testing & Optimization
Deployment strategies using platforms like Heroku, AWS, or Netlify. Environment setup, CI/CD pipelines, version control integration, and containerization basics. Security practices such as data encryption, input validation, and user access control. Testing techniques including unit tests, integration tests, and A/B testing are introduced. Analytics tools to monitor application performance and optimize load times and user flow and AI-enabled web applications. Adding integration of AI APIs (OpenAI GPT, Hugging Face Transformers) to built smart apps.

Text Books:

1. Flanagan, D. *JavaScript: The Definitive Guide*, O'Reilly Media.

2. Joshi, A. *Machine Learning for Web Applications*, Tech Press.

Reference Books:

1. Duckett, J. *HTML and CSS: Design and Build Websites*, Wiley.
2. Russell, S., & Norvig, P. *Artificial Intelligence: A Modern Approach*, Pearson.

Course Code	BAML303				
Category	Minor				
Course title	Mastering Data Handling - SQL & No-SQL				
Scheme & Credits	L	T	P	Credits	Semester
	3	1	0	4	III
Pre-requisite (if any)	Basic familiarity with data types and structures and Logical reasoning and simple mathematical skills				

Course Outcomes:

1. Understand database design and modelling for structured and unstructured data.
2. Perform SQL operations to query and manipulate relational data.
3. Use NoSQL concepts and MongoDB for handling document-based data.
4. Integrate database access in data pipelines.
5. Apply data handling knowledge to real-world analytics tasks.

Unit I: Introduction to Databases and Data Models

Types of databases: RDBMS vs NoSQL, Relational model: tables, rows, columns, Schema, Primary keys, foreign keys, normalization concepts, Introduction to MongoDB and JSON structure, Hands-on: Understanding database schemas and JSON documents

Unit II: SQL Fundamentals and Data Retrieval

SELECT statements, filtering data (WHERE, BETWEEN, LIKE), Sorting and limiting results (ORDER BY, LIMIT), Aggregation (COUNT, SUM, AVG, GROUP BY, HAVING), Joins (INNER, LEFT, RIGHT, FULL OUTER) , Hands-on: Queries to analyse structured business data

Unit III: Advanced SQL and Sub queries

Nested queries and sub queries, CASE, COALESCE, NULL handling, Temporary tables, views, and indexes, stored procedures and transactions, Hands-on: Complex querying using sub queries and joins

Unit IV: NoSQL Concepts and MongoDB

Document-based storage model in MongoDB, CRUD operations in MongoDB, Indexing and aggregation pipelines, Comparison of SQL vs NoSQL queries, Hands-on: Real-time operations with MongoDB shell or Compass

Unit V: Data Integration and Use Cases

Connecting databases with Python (using SQLAlchemy or PyMongo), Data extraction for visualization/reporting, use cases: Customer segmentation, product catalog, transaction logs, Hands-on: Building a data handler that reads from SQL and NoSQL sources. Includes data lakes, distributed data processing (Spark), and real-time data ingestion concepts for AI pipelines.

Text Books

1. Learning SQL – Alan Beaulieu
2. MongoDB: The Definitive Guide – Kristina Chodorow
3. SQL for Data Analytics – Upmani Sharma et al.

Course Code	BAML304				
Category	Core				
Course title	Introduction to Machine Learning				
Scheme & Credits	L	T	P	Credits	Semester III
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes:

1. Understand the fundamental concepts and types of machine learning.
2. Implement supervised learning algorithms such as linear and logistic regression.
3. Explore unsupervised learning methods like clustering and dimensionality reduction.
4. Apply model evaluation techniques to assess performance and avoid overfitting.
5. Build, train, and test basic ML models using Python and libraries like Scikit-learn.

Unit 1: Fundamentals of Machine Learning

Definition and scope of Machine Learning, differences between AI, ML, and Deep Learning. Types of learning: supervised, unsupervised, semi-supervised, and reinforcement learning. Applications of ML in various domains. Steps in developing a machine learning model. Data preprocessing: handling missing data, normalization, standardization, encoding categorical variables. Evaluation metrics: accuracy, precision, recall, F1-score. Challenges and limitations in ML.

Unit 2: Supervised Learning Techniques

Linear regression: model representation, cost function, gradient descent. Multiple linear regression and polynomial regression. Classification algorithms: logistic regression, K-nearest neighbors (KNN), decision trees, support vector machines (SVM). Overfitting and underfitting. Model validation: train-test split, k-fold cross-validation. Hyperparameter tuning and regularization methods: L1 and L2.

Unit 3: Unsupervised Learning Methods

Clustering techniques: K-means, hierarchical clustering, DBSCAN. Dimensionality reduction methods: Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), t-SNE. Feature selection and extraction. Association rule mining: support, confidence, lift. Applications of unsupervised learning in pattern recognition, anomaly detection, and recommendation systems.

Unit 4: Ensemble Methods and Model Evaluation

Ensemble learning: bagging, boosting, and stacking. Random Forest, AdaBoost, Gradient Boosting Machines (GBM), XGBoost. Model evaluation techniques: confusion matrix, ROC curve, AUC, precision-recall curve. Bias-variance tradeoff. Performance improvement using feature engineering and resampling techniques. Comparison between single and ensemble models.

Unit 5: Introduction to Neural Networks and Advanced Topics

Basic concepts of neural networks: perceptron, activation functions, multilayer perceptron (MLP). Forward and backward propagation. Introduction to deep learning and architectures like CNN and RNN. Applications in image and speech recognition. Basics of transfer learning. Brief overview of ML libraries: Scikit-learn, TensorFlow, Keras, PyTorch. ML ethics and fairness.

Text Books:

1. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly.
2. Tom M. Mitchell, *Machine Learning*, McGraw Hill.

Reference Books:

1. Alpaydin, Ethem. *Introduction to Machine Learning*, MIT Press.
2. Bishop, Christopher M. *Pattern Recognition and Machine Learning*, Springer.

Course Code	BAML312				
Category	Skill Based				
Course title	AI-Driven Web Application Development Lab				
Scheme & Credits	L	T	P	Credits	Semester
	0	0	4	2	III
Pre-requisite (if any)	None				

Course Outcomes:

1. Understand the structure and workflow of full-stack AI-driven web applications.
2. Build responsive front-end interfaces using HTML, CSS, and JavaScript frameworks.
3. Develop server-side logic and connect with databases using RESTful APIs.
4. Integrate AI/ML models into web applications using libraries such as TensorFlow.js or ML5.js.
5. Deploy, test, and maintain AI-powered web applications on cloud platforms.

List of Experiments:

1. **Basic Front-End Design**: Create a responsive web page using HTML5, CSS3, and JavaScript.
2. **React/Angular Front-End Setup:** Set up a basic single-page application (SPA) using React or Angular with routing and components.
3. **Form Handling and Validation**: Create a dynamic form with validation and user input handling.
4. **Server-Side Development with Node.js/Flask**: Set up a RESTful API using Node.js (Express) or Python Flask. Connect to a database (MongoDB/MySQL).
5. **Authentication and Session Management**: Implement user authentication using JWT and manage sessions and authorization.
6. **AI Integration: Chatbot or Recommendation Engine**: Integrate a basic AI model for chatbot or recommendations using TensorFlow.js or ML5.js.
7. **Real-Time Data and Web Sockets**: Implement real-time features (like live chat or notification) using WebSocket or Socket.io.
8. **AI Model Deployment in Front-End**: Load and run a pre-trained ML model in the browser (e.g., image classification using MobileNet in TensorFlow.js).
9. **Full-Stack AI Web Application**: Build and integrate a complete front-end and back-end with an AI model and user interface.
10. **Deployment on Cloud Platform**: Deploy the AI-driven web app using Heroku, Netlify, or AWS. Enable CI/CD pipeline using GitHub Actions or Jenkins.
11. **Building and Deploying an AI-Powered Web App with Streamlit and FastAPI:** To create an AI-based web application using a machine learning model, develop the backend API using FastAPI, and build a responsive user interface using Streamlit.

Reference Books:

1. **Flavio Copes**, *Fullstack Web Development with Node.js and React*, Independently Published.
2. **Aurélien Géron**, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly.
3. **Sanchit Jain**, *Web Development with Machine Learning Applications*, BPB Publications.

Course Code	BAML313				
Category	Skill Based				
Course title	Mastering Data Handling - SQL & No-SQL Lab				
Scheme & Credits	L	T	P	Credits	Semester
	0	0	4	2	III
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Apply SQL for realistic business data reporting and segmentation.
2. Use MongoDB for unstructured data handling and performance tuning.
3. Design normalized relational database schemas and implement queries using JOINs and sub queries.
4. Perform CRUD operations on NoSQL documents and structure collections for scalability.
5. Integrate SQL and NoSQL operations in hybrid systems for data analytics solutions.

List of Experiments

1. Project Title: Relational Database Design & Querying
Project Objective: Design a relational database and perform complex queries for a sales dataset.
Project Outcome: Apply SQL for realistic business data reporting and segmentation.

2. Project Title: NoSQL Product Catalog
Project Objective: Create a NoSQL document store for a product catalog and query it.
Project Outcome: Use MongoDB for unstructured data handling and performance tuning.

Software

- MySQL/PostgreSQL (Free)
- MongoDB (Free)
- MongoDB Compass / MySQL Workbench (Free)

Course Code	AUD 301				
Category	Audit Course				
Course title	Qualities of Consciousness				
Scheme & Credits	L	T	P	Credits	Semester
	2	0	0	0	III
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Define the basis of all living and understand the value of relative and absolute life.
2. Discuss about communication in various facets which involves scientific studies on effortless communication.
3. Classify listening skills in the light of consciousness which enables them to imbibe the important aspect of mindful listening which is integral part of communication.

Unit 1: Qualities of Consciousness

The nature of life is to grow, order is present everywhere, life is found in layers, and the outer depends on the inner. Seek the highest first, rest and activity are the steps of progress, enjoy greater efficiency and accomplish more, every action has a reaction.

Unit 2: Qualities of Consciousness

Purification leads to progress, the field of all possibilities is the source of all solutions, thought leads to action, action leads to achievement, and achievement leads to fulfillment. Knowledge is gained from inside and outside, knowledge is structured in consciousness, harmony exists in diversity, the whole is contained in every part, and the whole is greater than the sum of the parts.

Unit 3: Enrichment of Experiences III

Advance lectures on the Transcendental Meditation Program, follow-up sessions and group checkings, personal checkings.

Text Book (s):

1. Yogi. M Maharishi. (1963). Science of Being and Art of Living. Plume; Reissue edition.
2. Rosenthal Norman. (2016). Super Mind: How to Boost Performance and Live a Richer and Happier Life through Transcendental Meditation. Tarcher Perigee

References:

1. Strahan, J., Fogarty, G.J., Machin, A.M. (2005). Predicting performance on a situational judgement test: The role of communication skills, listening skills, and expertise. Proceedings of the 40 Annual Conference of the Australian Psychological Society, pp. 323-327, Sydney

Semester IV

Detailed Second Year Curriculum Contents

Course Code	BCSE401				
Category	Minor				
Course title	Cloud Computing				
Scheme & Credits	L	T	P	Credits	Semester IV
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcomes (COs):

1. Explain the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing.
2. Apply the fundamental concepts in datacenters to understand the tradeoffs in power, efficiency and cost
3. Identify resource management fundamentals, i.e. resource abstraction, sharing and sandboxing and outline their role in managing infrastructure in cloud computing.
4. Analyze various cloud programming models and apply them to solve problems on the cloud.
5. To expose the students to frontier areas of Cloud Computing and information systems, while providing sufficient foundations to enable further study and research.

Unit 1: Introduction
From collaborative to the Cloud, a short history of client–server computing, peer-to-peer computing, distributed computing, collaborative computing, cloud computing, functioning of cloud computing, cloud architecture, cloud storage, cloud services.

Unit 2: Business Values
Modeling services, infrastructure services, platform services, software services, software as service modes, massively scaled software as a service, scale of economy, management and administration.

Unit 3: Inside Cloud Computing
Feeling sensational about organization, administering cloud service, managing cloud resources.

Unit 4: Cloud Computing Technology
Fundamental concepts of compute, concepts of virtualization, levels of virtualization, benefits, advantages and disadvantages, storage virtualization, networking virtualization, desktop virtualization, application virtualization, server virtualization.

Unit 5: Virtualization Data Management
Hypervisor classifications, infrastructure requirements, virtual LAN and VSAN, cloud information security, cloud security services, virtualization security management.

Text Book (s):

1. Cloud computing a practical approach - Anthony T.Velte , Toby J. Velte Robert Elsenpeter, TATA McGraw- Hill , New Delhi – 2010
2. Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online - Michael Miller - Que 2008

References:

1. Cloud computing for dummies- Judith Hurwitz , Robin Bloor , Marcia Kaufman ,Fern Halper, Wiley Publishing, Inc, 2010

Course Code	BCSE402				
Category	Core				
Course title	Operating System				
Scheme & Credits	L	T	P	Credits	Semester IV
	3	1	0	4	
Pre-requisite (if any)	None				

COURSE OUTCOMES

1. The basics of the operating systems, mechanisms of OS to handle processes, threads, and their communication
2. The memory management and its allocation policies
3. Different conditions for deadlock and their possible solutions
4. The storage management policies with respect to different storage management technologies
5. The concept of the operating system with respect to UNIX, Linux, Time, and mobile OS.

Unit 1: Introduction

What is an Operating System, simple batch systems, multi-programmed batch systems, time-sharing systems, personal-computer systems, parallel systems, distributed systems, real-time systems, OS as a resource manager. Memory organization, memory hierarchy, memory management strategies, contiguous versus non-contiguous memory allocation, partition management techniques, logical versus physical address space, swapping, paging, segmentation, segmentation with paging, demand paging, page replacement, page-replacement algorithms, performance of demand paging, thrashing, demand segmentation, and overlay concepts.

Unit 2: Processes

Process states, process management, interrupts, inter-process communication, thread states, thread operations, threading models. Processor scheduling: scheduling levels, pre-emptive vs non-pre-emptive scheduling, priorities, scheduling objectives, scheduling criteria, scheduling algorithms, demand scheduling, real-time scheduling. Process synchronization: mutual exclusion, software and hardware solutions to mutual exclusion, semaphores, critical section problems. Case studies: Dining Philosopher Problem, Barber Shop Problem.

Unit 3: Deadlocks

Examples of deadlock, resource concepts, necessary conditions for deadlock, deadlock solutions, deadlock prevention, deadlock avoidance with Banker's algorithm, deadlock detection, deadlock recovery. Device management: disk scheduling strategies, rotational optimization, system considerations, caching and buffering.

Unit 4: File System

File system introduction, file organization, logical and physical file systems, file allocation strategy, free space management, file access control, data access techniques, data integrity protection. Case studies on file systems: FAT32, NTFS, Ext2/Ext3.

Unit 5: Disk Management

Disk structure, disk scheduling (FCFS, SSTF, SCAN, C-SCAN), disk reliability, disk formatting, boot block, bad blocks. Case studies on UNIX and Windows operating systems.

Text Book (s):

1. Deitel & Dietel, “Operating System”, Pearson, 3rd Ed., 2011
2. Silbersachatz and Galvin, “Operating System Concepts”, Pearson, 5th Ed., 2001
3. Madnick & Donovan, “Operating System”, TMH,1st Ed., 2001.

References:

1. Tannenbaum, “Operating Systems”, PHI, 4th Edition, 2000
2. Godbole, “Operating Systems”, Tata McGraw Hill, 3rd edition, 2014
3. Chauhan, “Principles of Operating Systems”, Oxford Uni. Press, 2014
4. Dhamdhere, “Operating Systems”, Tata McGraw Hill, 3rd edition, 2012
5. Loomis, “Data Management & File Structure”, PHI, 2nd Ed.

Course Code	BCSE403				
Category	Core				
Course title	Theory of Computation				
Scheme & Credits	L	T	P	Credits	Semester IV
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcomes (COs):

1. Concept of formal grammar, formal language, regular expression and automata machine.
2. Finite automata and push down automata (PDA) machines for given formal languages or computational real-world problem statements
3. The capability of Turing machine and design Turing Machine for context-sensitive languages or computational real-world problem statements.
4. Automata for modeling the solution for various computational engineering problems.
5. The concepts of tractable & untraceable problems and able to decide a given problem is tractable or not.

Unit 1: Introduction

Overview of alphabets, strings, and languages. Chomsky classification of languages. Finite Automata, Deterministic Finite Automata (DFA), and Nondeterministic Finite Automata (NDFA). Equivalence of NDFA and DFA, minimization of finite automata, Moore and Mealy machines and their equivalence. Regular expressions and Kleene's Theorem (with proof), closure properties of regular languages, and Pumping Lemma for regular languages (with proof).

Unit 2: Context Free Grammar

Context-free grammar, derivation trees, ambiguity in grammar and its removal, simplification of context-free grammar. Normal forms for CFGs: Chomsky Normal Form and Greibach Normal Form. Pumping Lemma for context-free languages. Closure properties of CFL (proof required), Push Down Automata (PDA), deterministic PDA, nondeterministic PDA, equivalence of PDA and CFG. Overview of LEX and YACC.

Unit 3: Turing Machines

Turing machines, Turing-Church Thesis, variants and equivalence of Turing machines, recursive and recursively enumerable languages, halting problem, undecidability, and examples of undecidable problems.

Unit 4: Complexity Classes

Introduction to complexity classes, computability and intractability, time complexity, and complexity classes P, NP, and Co-NP.

Unit 5: Cook's Theorem

Proof of Cook's Theorem, space complexity, complexity classes SPACE and PSPACE, proof of Savitch's Theorem, and complexity classes L, NL, and Co-NL.

Text Books:

1. Hopcroft, John E.; Motwani, Rajeev; Ullman, Jeffrey D "Introduction to Automata Theory,Languages, and Computation", Third Edition, Pearson.
2. Sipser, Michael," Introduction to the theory of Computation", Third Edition, Cengage.

References Books:

1. Martin J. C., "Introduction to Languages and Theory of Computations", Third Edition, TMH.
2. Papadimitrou, C. and Lewis, C.L., "Elements of the Theory of Computation", PHI.
3. Daniel I.A. Cohen," Introduction to Computer Theory",Second Edition, John Wiley.

Course Code	BAML404				
Category	Core				
Course title	Data Analysis & Visualization using Python				
Scheme & Credits	L	T	P	Credits	Semester IV
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcome (COs):

1. Import, clean, and transform datasets for analysis.
2. Perform exploratory data analysis using Pandas.
3. Visualize insights using static and interactive charts.
4. Build dashboards and web-based visual reports.
5. Derive actionable insights through data storytelling.

Unit 1: Data Analysis Foundations

Introduction to the data analysis lifecycle, data types and data frames in Pandas, data importing from CSV, Excel, and SQL databases. Data cleaning techniques including handling missing values, removing duplicates, and type conversion. Hands-on practice involves loading and cleaning real-world datasets.

Unit 2: Exploratory Data Analysis (EDA)

Descriptive statistics and summary functions, groupby and aggregation operations, correlation and covariance analysis, understanding feature distribution, and identifying outliers. Hands-on practice includes performing EDA on business-related datasets.

Unit 3: Data Visualization with Matplotlib and Seaborn

Creating basic plots such as line, bar, scatter, and histogram, along with advanced charts like box plot, violin plot, and heatmaps. Plot customization through titles, legends, axes, colors, annotations, and styles. Hands-on practice emphasizes visual storytelling with data.

Unit 4: Interactive Visualizations and Dashboards

Introduction to Plotly and interactive widgets for creating subplots, drop-downs, and sliders. Basic usage of Streamlit for dashboard creation and integration of visualizations into mini applications. Hands-on activity focuses on developing a business dashboard project.

Unit 5: Case Study and Project Work

Case study implementation involving EDA on datasets from marketing, sales, HR, or finance domains. Generating visual reports using Jupyter Notebook, practicing data storytelling, and creating insightful presentations. The unit culminates in a final report and project presentation.

Text Book(s):

1. Python for Data Analysis – Wes McKinney
2. Practical Statistics for Data Scientists – Peter Bruce, Andrew Bruce
3. Storytelling with Data – Cole Nussbaumer Knaflic

Course Code	VAC401				
Category	Value Added				
Course title	Professional Ethics				
Scheme & Credits	L	T	P	Credits	Semester IV
	2	0	0	2	
Pre-requisite (if any)	None				

Course outcomes (COs):

1. The students will learn to facilitate the students with the concepts of Professional Ethics and to make them understand its Importance.
2. Demonstrate a thorough understanding of the principles of professional ethics in commerce.
3. Apply ethical theories and decision-making models to resolve ethical issues.
4. Evaluate the impact of corporate social responsibility initiatives on business performance.

Unit 1: Introduction:
Meaning and Characteristics of Ethics, Concepts & Relevance of Business Ethics, Ethical & Unethical Behaviour in Management, Factors influencing Business Ethics Concept, Characteristics, and Classification of Values, Ethics, Morality and Value System, Ethics & Moral Decision Making, Factors affecting Values, Developing Value System in an Organisation, Values in Business Management, Values for Indian Managers, International Business ethics. Corporate Governance: Meaning, Objectives, Need, and OECD Principles of Corporate Governance, SEBI Code of Corporate Governance, Corporate Disclosure and Investor Protection in India.

Unit 2: Corporate Social Responsibility:
Meaning and Concept of Social Responsibility of Business, Levels & Approaches to Social Responsibility, Principles & Dimensions of Corporate Social Responsibility towards various Stakeholders.

Unit 3: Contemporary Ethical Issues and Benchmarking:
Meaning & Features of Indian Ethos, Principles of Indian Ethos in Management, Spiritual Managerial Values, 5 C's & holistic View to Management. Relevance of Mahabharata and Ramayana in Management, Trans-Cultural Human Values in Management Education, Meaning & Features of Benchmarking, Process and Types of Benchmarking

Text Book(s):

1. Welfel, E. R. (2016). Ethics in counseling and psychotherapy: Standards, research, and emerging issues (6th ed). Cengage Learning.
2. Remley, T. P., & Herlihy, B. (2020). Ethical, legal, and professional issues in counseling (6th ed.). Pearson.
3. Koocher, G. P., & Keith-Spiegel, P. (2008). Ethics in psychology and the mental health professions: Standards and cases (3rd ed.). Oxford University Press.

Course Code	BAML414				
Category	Core				
Course title	Data Analysis & Visualization using Python Lab				
Scheme & Credits	L	T	P	Credits	Semester IV
	0	0	4	2	
Pre-requisite (if any)	None				

Course outcomes (COs):

1. Discover trends and communicate patterns with plots.
2. Build dashboards to present analysis results to stakeholders.
3. Apply data cleaning, transformation, and grouping techniques using Pandas.
4. Generate various static and interactive visualizations using Seaborn and Plotly.
5. Combine EDA and visualization into a coherent report using Streamlit interface.

List of Experiments

1. Project Title: Exploratory Data Analysis (EDA)
Project Objective: Perform EDA and generate insights from raw business data.
Project Outcome: Discover trends and communicate patterns with plots.

2. Project Title: Interactive Dashboard using Streamlit
Project Objective: Build an interactive dashboard using Streamlit.
Project Outcome: Build dashboards to present analysis results to stakeholders.

Software

● Python, Pandas, Seaborn, Matplotlib, Plotly, Streamlit

Course Code	BCSE421				
Category	Skill Based				
Course title	Seminar				
Scheme & Credits	L	T	P	Credits	Semester IV
	0	0	4	2	
Pre-requisite (if any)	None				

The objective of the Seminar is to enhance students' understanding and communication skills by encouraging them to explore, analyze, and present recent advancements and emerging trends in the field of Artificial Intelligence and Machine Learning. Students are expected to select a contemporary topic, carry out an in-depth literature survey, and deliver a structured presentation supported by technical content.

The seminar should promote independent learning, critical thinking, and the ability to effectively communicate complex ideas through oral and written formats. Topics may include areas such as generative AI, ethical AI, reinforcement learning, AI in healthcare, edge AI, and other cutting-edge developments.

Note: Guidelines for topic selection, presentation structure, and report format are provided in separate documents.

Course Code	AUD 401				
Category	Audit Course				
Course title	Art of Living for fulfilment of Life				
Scheme & Credits	L	T	P	Credits	Semester IV
	2	0	0	0	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the concept of Being as the foundational aspect of life and explore its Absolute and Relative dimensions to enhance personal awareness and inner fulfillment.
2. Apply the Art of Living principles—including thinking, speaking, acting, and behavior—to achieve harmony between material and spiritual values, and cultivate confidence, success, and effective relationships.
3. Demonstrate the ability to engage in Effortless Communication by understanding the role of consciousness and employing scientifically supported techniques for clear, spontaneous, and effective information exchange.

Unit - I: Science of Being

Being, the basis of all Living, Being, the Absolute and the Relative, how to contact and live Being

Unit - II: Art of Living and Enjoying Fulfillment

Art of Being: Harmony of Material and Spiritual Values, Art of Being: How to live life in Eternal Freedom while Accomplishing the Maximum in the World, Art of Thinking: Key to Clear, Powerful and Fruitful Thinking, Art of Speaking: Key to Speaking with Maximum Effectiveness, Art of Action: Key to Self-confidence, Increased Efficiency, and Success in undertakings, Art of Behavior: Key to Fruitful Relationships, Life in Fulfillment: Fulfillment of Life, Religion, Psychology and Philosophy

Unit - III: Effortless Communication: Frictionless flow of Information

What is Communication, Keys to effective communication, Consciousness as the basis of the Spontaneous Right Communication, Overview of Scientific Studies on Effortless Communication

Text Book (s):

1. Yogi.M. Maharishi. (1963). Science of Being and Art of Living. Plume; Reissue edition.
2. Dalio Ray. (2017). Principles: Life and Work. Simon & Schuster

Semester V

Detailed Third Year Curriculum Contents

Course Code	BCSE501				
Category	Core				
Course title	Computer Networks				
Scheme & Credits	L	T	P	Credits	Semester V
	3	1	0	4	
Pre-requisite (if any)	None				

Course outcome (COs):

1. Understand and contrast the concept of Signals, OSI & TCP/IP reference models and discuss the functionalities of each layer in these models
2. Discuss and Analyze flow control and error control mechanisms and apply them using standard data link layer protocols
3. Design subnets and calculate the IP addresses to fulfil network requirements of an organization
4. Analyze and apply various routing algorithms to find shortest paths for packet delivery.CO5: Explain the details of Transport Layer Protocols (UDP, TCP) and suggest appropriate protocol in reliable/unreliable communication.

Unit 1: Introduction Concepts

Goals and applications of networks, network structure and architecture, the OSI reference model, services, network topology design, delay analysis, backbone design, local access network design, physical layer transmission media, switching methods, ISDN, and terminal handling.

Unit 2: Medium Access Sub Layer

Medium access sub layer, channel allocations, LAN protocols including ALOHA protocols, overview of IEEE standards such as FDDI, data link layer, elementary data link protocols, sliding window protocols, and error handling.

Unit 3: Network Layer

Network layer concepts including point-to-point networks, routing, congestion control, internetworking with TCP/IP, IP packet structure, IP address, and an introduction to IPv6.

Unit 4: Transport Layer

Transport layer design issues and connection management, session layer design issues and remote procedure calls, presentation layer design issues, data compression techniques, cryptography, and TCP window management.

Unit 5: Application Layer

Application layer functionalities including file transfer, access and management, electronic mail, virtual terminals, and other applications. Also includes example networks such as the Internet and public networks.

Text Book (s):

1. Forouzan Behrouz A. (2011), “Data communication and Networking”, Tata McGraw – Hill.
2. Tanenbaum Andrew S, Computer Networks, 4th Edition, Pearson Education.

References:

1. Uyless Black, "Computer Networks-Protocols, Standards and Interfaces", 2nd edition, PHI, 1996.
2. Dimitri Bertsekas and Robert Gallager, “Data Networks", PHI.

Course Code	BAML502				
Category	Core				
Course title	Machine Learning and AI: A Deep Dive				
Scheme & Credits	L	T	P	Credits	Semester V
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcome

1. Understand core ML concepts and types.
2. Implement regression and classification models.
3. Evaluate and improve ML model performance.
4. Perform unsupervised learning on datasets.
5. Build and explain ML-based solutions.

Unit I: Machine Learning Foundations

What is ML? AI vs ML vs DL, Types of ML: Supervised, unsupervised, reinforcement learning, ML pipeline: loading, preparing, modelling, Introduction to Scikit-learn, Hands-on: Building your first ML model

Unit II: Supervised Learning – Regression

Linear and polynomial regression, Evaluation metrics: MAE, MSE, RMSE, R^2, Overfitting, underfitting, regularization, Feature scaling and transformations, Hands-on: Predictive modeling using real datasets,

Unit III: Supervised Learning – Classification

Logistic regression, KNN, Decision Trees, Random Forests, Confusion matrix, accuracy, precision, recall, F1-score, ROC-AUC, cross-validation, Hands-on: Classification case study (HR churn, fraud detection)

Unit IV: Unsupervised Learning

K-means clustering and elbow method, Hierarchical clustering, DBSCAN, Dimensionality reduction with PCA, Hands-on: Customer segmentation or anomaly detection

Unit V: Model Improvement, Hyperparameter Tuning and LLMs

GridSearchCV and Randomized Search CV, Feature selection and importance, Model explainability (SHAP, LIME intro), Hands-on: Model improvement project, In-depth coverage of Transformers, attention mechanisms, and Large Language Models (LLMs).

Text Book(s):

1. Hands-On ML with Scikit-Learn, Keras & TensorFlow – Aurelien Geron
2. Python Machine Learning – Sebastian Raschka

Course Code	BAML503				
Category	Core				
Course title	Software Engineering & DevOps				
Scheme & Credits	L	T	P	Credits	Semester V
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles, models, and methodologies of software engineering.
2. Apply software process models and requirement engineering techniques in real projects.
3. Design, develop, and test software using modern architectural and modelling tools.
4. Comprehend the principles of DevOps for continuous integration and delivery.
5. Use version control, automation, and containerization tools for efficient DevOps practices.

Unit 1: Software Engineering Foundations

Introduction to Software Engineering, Software characteristics, Software development challenges. Software process models: Waterfall, Incremental, Spiral, V-Model, Agile. Software project management: effort estimation, scheduling, risk analysis, and quality assurance. Software development life cycle (SDLC) phases overview. Role of software engineering in system development and maintenance.

Unit 2: Requirement Engineering and Software Design

Requirement elicitation, specification, validation, and management. Functional and non-functional requirements. Use cases, user stories, and software requirement specification (SRS). Software design principles: modularity, cohesion, coupling. Design models: Data Flow Diagrams (DFDs), UML diagrams—class, sequence, activity, and use case diagrams. Architectural styles: layered, client-server, microservices.

Unit 3: Software Development and Testing

Coding standards, code review, and debugging techniques. Introduction to software testing: unit testing, integration testing, system testing, and acceptance testing. Black box and white box testing techniques. Test-driven development (TDD). Defect tracking and management. Introduction to software quality models and standards like ISO and CMMI.

Unit 4: DevOps Concepts and Practices

Introduction to DevOps: principles, goals, and lifecycle. Key practices: Continuous Integration (CI), Continuous Delivery (CD), Infrastructure as Code (IaC). Version control systems: Git, branching strategies. DevOps pipeline stages. Introduction to build tools (Maven, Gradle) and CI/CD tools (Jenkins, GitLab CI). Collaboration between development and operations teams.

Unit 5: DevOps Automation Tools and Cloud Deployment

Containerization using Docker: images, containers, Dockerfile. Orchestration using Kubernetes. Configuration management tools: Ansible, Puppet. Monitoring and logging tools: Prometheus, Grafana, ELK stack. Cloud platforms overview: AWS, Azure, Google Cloud. Deployment strategies: blue-green, rolling, canary. Security and compliance in DevOps pipelines.

Text Books:

1. Ian Sommerville, *Software Engineering*, Pearson Education.
2. Len Bass, Ingo Weber, Liming Zhu, *DevOps: A Software Architect's Perspective*, Addison-Wesley.

Reference Books:

1. Rajib Mall, *Fundamentals of Software Engineering*, PHI Learning.
2. Gene Kim, Jez Humble, Patrick Debois, John Willis, *The DevOps Handbook*, IT Revolution Press.

Course Code	BAML504				
Category	Core				
Course title	Optimization Techniques in Machine Learning				
Scheme & Credits	L	T	P	Credits	Semester V
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand mathematical foundations and types of optimizations used in machine learning.
2. Apply gradient-based optimization algorithms for model training.
3. Analyze convex and non-convex optimization problems in learning tasks.
4. Implement constrained and unconstrained optimization methods.
5. Use optimization libraries and tools for efficient ML model performance.

Unit 1: Mathematical Foundations of Optimization

Introduction to optimization and its role in machine learning. Types of optimization problems: linear, nonlinear, convex, and non-convex. Objective functions, constraints, and feasible regions. Convex sets and convex functions. Optimality conditions: local vs global minima. Review of essential mathematical concepts: vector calculus, partial derivatives, Jacobian and Hessian matrices.

Unit 2: Unconstrained Optimization Techniques

Gradient Descent and variants: Batch, Stochastic (SGD), Mini-batch. Convergence analysis and step-size (learning rate) tuning. Momentum-based methods: Momentum, Nesterov Accelerated Gradient (NAG). Newton's Method and Quasi-Newton Methods (BFGS, L-BFGS). Problems of local minima, saddle points, and vanishing/exploding gradients.

Unit 3: Constrained Optimization and Lagrangian Methods

Formulation of constrained optimization problems. Lagrange multipliers and KKT conditions. Duality in optimization. Projected Gradient Descent. Penalty and Barrier methods. Applications in support vector machines, logistic regression, and neural network regularization. Introduction to Quadratic Programming (QP) and Linear Programming (LP) problems.

Unit 4: Advanced Optimization Algorithms in ML

Adaptive learning rate algorithms: Adagrad, RMSProp, Adam, Nadam, and their use in deep learning. Coordinate Descent and Proximal Gradient Methods. Hyperparameter optimization: Grid Search, Random Search, Bayesian Optimization. Evolutionary algorithms: Genetic Algorithms and Particle Swarm Optimization. Use of optimization in feature selection and dimensionality reduction.

Unit 5: Optimization Tools and Applications

Optimization in loss function minimization for regression and classification. Use of optimization in clustering, recommendation, and reinforcement learning. Implementation using Python libraries: SciPy, TensorFlow, PyTorch optimizers, Optuna. Case studies from computer vision and natural language processing. Challenges in large-scale and real-time optimization.

Text Books:

1. S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press.
2. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly.

Reference Books:

1. D. P. Bertsekas, *Nonlinear Programming*, Athena Scientific.
2. Y. Nesterov, *Introductory Lectures on Convex Optimization: A Basic Course*, Springer.

Course Code	BECC511				
Category	Skill Based				
Course title	Robotics Lab				
Scheme & Credits	L	T	P	Credits	Semester V
	0	0	4	2	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understanding basic robotics principles.
2. Learning mechanical design and electronics.
3. Developing programming skills for robots.
4. Understanding robot perception and sensing.
5. Exploring robotics applications across industries.

List of Experiments:

1. Power supply +5 volt using IC 7805
2. Interfacing RGB LED with Arduino
3. Controlling Brightness of LED Using Potentiometer
4. Design and implementation of 4 Wheel wireless Robot
5. Design and implementation of Line follower Robot
6. Implementation of Motorized Robotic Arm
7. Implementation of an Ultrasonic Distance Measuring Module for Autonomous Robot Navigation
8. Wi-Fi Connectivity Implementation and testing using NodeMCU
9. Remote Monitoring of Environmental Parameters using NodeMCU and DHT11 Sensor
10. Implementation of a Smart Home Assistant Robot Using NodeMCU and Blynk Iot

Text Book (s):

1. Tocci R J and Widmer N S, "Digital Systems - Principles and Applications", 8th Ed., Pearson Education India, New Delhi (2001).
2. Boylestad and Nashelsky, "Electronic Devices and Circuit Theory", 8thEd., Pearson Education India, New Delhi(2002)

References:

1. Bhargava-BasicElectronics&Linear Circuits, TMH
2. arduino.cc
3. Introduction to Robotics: Mechanics and Control

Course Code	BOOC515/BAML515				
Category	Internship				
Course title	MOOC/Internship				
Scheme & Credits	L	T	P	Credits	Semester V
	0	0	4	2	
Pre-requisite (if any)	None				

MOOC (BOOC603)									
Sl No		Course Code	Semester	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	MOOC	BOOC603	6	MOOC		50	-	50	2
	1. Students opting for MOOC must enrol in one of the listed and approved courses, which should be technology-related and carry a minimum of 2 credits. 2. Students are required to successfully complete the selected course and submit the certificate by the university's specified due date. 3. The NPTEL certification score will be considered for internal and external assessment. If needed, scaling or conversion will be applied as per university guidelines.								

MOOC Approved Courses			
Sl. No.	Name	Host Institute	Direct Link (NPTEL/SWAYAM)
1	AI for All using Python	IIT Madras	https://swayam-plus.swayam2.ac.in/ai-for-all-courses
2	Machine Learning for Core Engineering Disciplines	IIT Madras	https://onlinecourses.nptel.ac.in/noc25_cs50/preview
3	Machine Learning	IIIT Delhi	https://onlinecourses.nptel.ac.in/noc24_cs110/preview
4	Deep Learning	IIT Ropar / IIT KGP	https://onlinecourses.nptel.ac.in/noc24_cs88/preview
5	Applied Accelerated Artificial Intelligence	IIT Palakkad	https://nptel.ac.in/courses/106106238

Internship (BAML603)									
Sl No		Course Code	Semester	Course Title	L-T-P	CIA Marks	ESE Marks	Total	Credit
1	Internship	BAML603	6	Internship		50	-	50	2
	◇ **Confirmation Required:** If the Students opting for an internship in the 5th semester must confirm their choice at the end of the 4th semester.								
	◇ **45-Day Training Mandatory:** A 45-day summer training/internship must be completed after the 4th semester.								
	◇ **Document Submission:** Certificate, internship/training report, and any other required documents must be submitted as per the university's notified schedule.								

Open Elective – I

Course Code	BEOE501				
Category	Open Elective				
Course title	Principles of Management				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the basic concepts, evolution, and functions of management.
2. Apply planning and decision-making processes in organizational contexts.
3. Analyze organizational structures and understand delegation and decentralization.
4. Demonstrate knowledge of leadership, motivation, and communication in management.
5. Examine the control process and appreciate modern trends like TQM, Agile, and AI in management.

Unit 1: Introduction to Management

Definition, Nature, and Scope of Management, Evolution of Management Thought (Taylor, Fayol, etc.), Functions of Management: Planning, Organizing, Staffing, Directing, Controlling, Roles and Responsibilities of a Manager, Levels of Management.

Unit 2: Planning and Decision Making

Meaning, Need, and Importance of Planning, Types of Plans (Strategic, Tactical, Operational), Planning Process, Objectives and MBO (Management by Objectives), Decision Making: Types, Process, and Techniques.

Unit 3: Organizing

Principles of Organizing, Organizational Structure: Functional, Divisional, Matrix, Authority, Responsibility & Accountability, Delegation and Decentralization, Departmentation.

Unit 4: Staffing and Directing

Staffing Process: Manpower Planning, Recruitment, Selection, Training, Leadership: Styles and Theories (Trait, Behavioral, Situational), Motivation: Maslow, Herzberg, McGregor, Communication: Process, Types, and Barriers, Coordination and Team Building.

Unit 5: Controlling and Contemporary Issues

Meaning and Process of Control, Types of Control: Feed-forward, Concurrent, Feedback, Control Techniques: Budgetary Control, Performance Appraisal, Audits. Recent Trends in Management: Agile Management, Quality Management (TQM, Six Sigma), Change Management, Technology and AI in Management

Text Book:

1. Harold Koontz and Heinz Weihrich, "Essentials of Management", McGraw Hill Education, 10th Edition, 2015.
2. Stephen P. Robbins and Mary Coulter, "Management", Pearson Education, 14th Edition, 2018.
3. P.C. Tripathi and P.N. Reddy, "Principles of Management", McGraw Hill Education, 6th Edition, 2017.

Reference Books:

1. James A.F. Stoner, R. Edward Freeman, and Daniel R. Gilbert, "Management", Pearson Education, 6th Edition, 2018.
2. Peter F. Drucker, "The Practice of Management", Harper Business, Reprint Edition, 2006.
3. Ricky W. Griffin, "Management: Principles and Practices", Cengage Learning, 11th Edition,2016.

Course Code	BEOE502				
Category	Open Elective				
Course title	Organizational Behavior				
Scheme & Credits	L	T	P	Credits	Semester V
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamental concepts and importance of Organizational Behaviors in technology-oriented firms.
2. Analyze individual and group behavior in organizations and understand their impact on organizational effectiveness.
3. Apply motivational theories to develop strategies for improving employee performance in AI/ML-driven organizations.
4. Evaluate leadership styles and their applicability in managing tech-based and cross-functional teams.
5. Examine organizational change and development in the context of rapid AI-driven transformations.

Unit I: Introduction to Organizational Behaviors

Definition, Nature, Scope, and Importance, Challenges & Opportunities in OB, Evolution and Theoretical Frameworks, OB in the context of AI/ML and tech organizations

Unit II: Individual Behaviors

Personality: Traits, MBTI, Big Five, Perception and Attribution, Learning Theories and Applications, Values, Attitudes, and Job Satisfaction

Unit III: Motivation

Motivation: Concept and Importance, Theories of Motivation: Maslow, Herzberg, McClelland, Vroom, and Equity Theory, Application in Tech Teams and Startups, Motivation through Job Design and AI-enabled performance management

Unit IV: Group Behaviors and Team Dynamics

Group Formation, Types, and Structure, Team Building and Virtual Teams, Conflict Management, Group Decision Making and Role of AI Tools in Collaboration

Unit V: Leadership and Communication

Leadership Theories: Trait, Behavioral, Contingency, Contemporary Leadership Styles: Transformational, Servant, Agile Leadership, Communication Process and Barriers, Technology in Organizational Communication

Unit VI: Organizational Culture, Change and Development

Organizational Culture and Climate, Managing Organizational Change, Resistance to Change and Overcoming Strategies, Organizational Development and Role of Data/AI in Change Management.

Textbooks:

1. Stephen P. Robbins & Timothy A. Judge, "Organizational Behavior", Pearson Education, 18th Edition, 2019.
2. Fred Luthans, "Organizational Behavior: An Evidence-Based Approach", McGraw-Hill Education, 13th Edition, 2010.
3. Ricky W. Griffin & Gregory Moorhead, "Organizational Behavior: Managing People and Organizations", Cengage Learning, 11th Edition, 2014.

Reference Books

1. K. Aswathappa, "Organizational Behavior", Himalaya Publishing House, 11th Revised Edition, 2020.
2. Ray French, "Organizational Behavior", Oxford University Press, 2nd Edition, 2011.

Course Code	BEOE503				
Category	Open Elective				
Course title	Business Intelligence				
Scheme & Credits	L	T	P	Credits	Semester V
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals and role of Business Intelligence in decision-making processes in modern AI/ML-driven enterprises.
2. Design and implement Data Warehousing solutions and understand the architecture and lifecycle.
3. Apply OLAP and data mining techniques for pattern discovery and business forecasting.
4. Evaluate different BI tools and platforms for dashboards, reporting, and performance metrics.
5. Apply BI techniques in real-time business scenarios and build intelligent solutions integrated with AI systems.

Unit I: Introduction to Business Intelligence

Definition, Scope, and Importance of BI,BI vs. Data Analytics vs. Data Science, Components of BI System, Role of BI in AI/ML Ecosystem, I Lifecycle and Architecture

Unit II: Data Warehousing

Concepts of Data Warehousing, Architecture: ETL Process, Data Marts, Metadata, Star, Snowflake, and Fact Constellation Schemas, Data Quality and Governance, Dimensional Modeling and Design

Unit III: Online Analytical Processing (OLAP)

OLAP Concepts and Types (ROLAP, MOLAP, HOLAP), OLAP Operations: Slice, Dice, Drill-Down, Roll-Up, LAP Cube Design, Implementation Using BI Tools

Unit IV: Data Mining for Business Intelligence

Introduction to Data Mining, Association Rules, Classification, Clustering, Predictive Modeling and Forecasting, Application of AI/ML in BI Systems

Unit V: BI Tools and Applications

Dashboards and Scorecards, Reporting Tools (Power BI, Tableau, etc.),KPI Development and Performance Metrics, I for Functional Areas: Marketing, Finance, HR, Operations, Real-time BI and Mobile BI Case Studies in Retail, Banking, Healthcare, and E-commerce, Self-Service BI, Cloud-based BI,BI and Big Data Integration, Ethical Issues and Data Privacy in BI

Textbooks

1. David Loshin, "Business Intelligence: The Savvy Manager's Guide", Morgan Kaufmann, 2nd Edition, 2012.
2. Ramesh Sharda, Dursun Delen, Efraim Turban, "Business Intelligence: A Managerial Perspective on Analytics", Pearson, 3rd Edition, 2014.
3. Larissa T. Moss, Shaku Atre, "Business Intelligence Roadmap: The Complete Project Lifecycle for Decision-Support Applications", Addison-Wesley, 1st Edition, 2003.

Reference Books

1. Cindi Howson, "Successful Business Intelligence: Secrets to Making BI a Killer App", McGraw Hill, 2nd Edition, 2013.
2. Galit Shmueli, Peter C. Bruce, Nitin R. Patel, "Data Mining for Business Intelligence", Wiley, 2nd Edition, 2010.
3. Rajiv Sabherwal, Irma Becerra-Fernandez, "Business Intelligence: Practices, Technologies, and Management", Wiley, 1st Edition, 2010.

Course Code	BEOE504				
Category	Open Elective				
Course title	Fintech Services				
Scheme & Credits	L	T	P	Credits	Semester V
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals of Fin-tech, its evolution, and its role in transforming traditional financial services.
2. Analyze the applications of AI/ML in financial services such as credit scoring, fraud detection, robo-advisory, and algorithmic trading.
3. Evaluate digital payment systems, block chain, crypto currencies, and lending platforms.
4. Explore the regulatory framework, cyber security concerns, and ethical implications of Fintech.
5. Design Fintech solutions and evaluate their effectiveness using data-driven approaches.

Unit I: Introduction to Fintech

Definition, History, and Evolution of Fintech, Fintech Ecosystem and Stakeholders, Key Technologies: AI, ML, Block chain, APIs, Cloud, Fintech vs Traditional Finance, Overview of Fintech Startups and Innovations

Unit II: AI & ML in Financial Services

Applications: Credit Scoring, Fraud Detection, Risk Assessment, Robo-Advisors and Automated Wealth Management, AI in Insurance (InsurTech), Lending (LendTech), Predictive Analytics in Finance, Case Studies and Use Cases

Unit III: Digital Payments and Lending Platforms

Mobile Payments, UPI, Wallets, POS, Peer-to-Peer (P2P) Lending and Crowd funding, BNPL (Buy Now Pay Later) Models, Digital KYC and Identity Verification, Role of AI/ML in Payment Fraud Detection.

Unit IV: Block chain and Crypto currencies

Introduction to Block chain and Distributed Ledger Technology, Bitcoin, Ethereum, and Other Crypto currencies, Smart Contracts and Decentralized Finance (DeFi),Central Bank Digital Currency (CBDC),Challenges and Opportunities

Unit V: Regulations, Security, and Ethics

Regulatory Bodies and Fintech Laws (RBI, SEBI, etc.),Cyber security in Fintech, Data Privacy and Consumer Protection, Ethical Issues in AI-Driven Finance, Future Trends and Innovation in Fintech.

Textbooks

1. Susanne Chishti, Janos Barberis, "The FINTECH Book", Wiley, 1st Edition, 2016.
2. Parag Y. Arjunwadkar, "Fintech: The Technology Driving Disruption in the Financial Services Industry", Wiley India, 1st Edition, 2018.
3. Douglas W. Arner, Ross P. Buckley, Dirk A. Zetzsche, "FinTech and RegTech in a Nutshell", Elgar Publishing, 1st Edition, 2021.

Reference Books

1. Chris Skinner, "Digital Bank: Strategies to Launch or Become a Digital Bank", Marshall Cavendish International, 2nd Edition, 2018.
2. Agustin Rubini, "Fintech in a Flash: Financial Technology Made Easy", CreateSpace Independent Publishing, 1st Edition, 2017.
3. Varun Bajaj, "FinTech: AI and Block chain Revolution", BPB Publications, 1st Edition, 2021.

Semester VI

Detailed Third Year Curriculum Contents

Course Code	BAML601				
Category	Core				
Course title	Applied Deep Learning				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the architecture of deep neural networks.
2. Build and train CNNs and RNNs using real-world data.
3. Leverage transfer learning for domain-specific models.
4. Develop and evaluate deep learning-based solutions.
5. Execute end-to-end DL workflows for various use cases.

Unit 1: Deep Learning Foundations

Perceptron and activation functions, loss functions and optimization, forward and backpropagation, batch normalization, dropout, hands-on implementation of a neural network from scratch.

Unit 2: CNNs and Image Processing

Convolution, pooling, padding, CNN architecture and design, image classification use cases, data augmentation techniques, hands-on project to build an image classifier using CNN.

Unit 3: RNNs and Sequence Models

RNN, LSTM, GRU architectures, applications in text generation and sentiment analysis, vanishing gradients and solutions, hands-on implementation of time-series prediction or text classification.

Unit 4: Transfer Learning and Pretrained Models

Feature extraction and fine-tuning, using models like VGG, ResNet, MobileNet, customizing pretrained models for new tasks, hands-on development of a transfer learning-based image classifier.

Unit 5: Deep Learning Applications and Case Study

Generative AI modules: GANs, Variational Autoencoders, Diffusion Models. End-to-end deep learning project setup, case studies in medical imaging and document processing, deployment-ready packaging of models, hands-on development of a deep learning mini project.

Text Book(s):

1. Deep Learning with Python – François Chollet
2. Neural Networks and Deep Learning – Michael Nielsen

Course Code	BAML602				
Category	Minor				
Course title	Soft Computing				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles and components of soft computing techniques.
2. Apply fuzzy logic for approximate reasoning and control.
3. Design and train artificial neural networks for pattern recognition and prediction.
4. Utilize genetic algorithms for solving optimization problems.
5. Integrate hybrid soft computing models for real-world applications.

Unit 1: Introduction to Soft Computing
Overview of soft computing and hard computing. Soft computing constituents: fuzzy logic, neural networks, genetic algorithms, and probabilistic reasoning. Applications and scope in engineering and decision-making. Comparison of conventional and soft computing techniques. Introduction to computational intelligence and approximate reasoning.

Unit 2: Fuzzy Logic and Systems
Fuzzy sets and membership functions. Fuzzy set operations and properties. Fuzzy relations and composition. Fuzzy inference systems: Mamdani and Sugeno models. Fuzzification and defuzzification methods. Fuzzy rule-based systems. Applications of fuzzy logic in control systems, decision-making, and classification problems.

Unit 3: Artificial Neural Networks (ANN)
Biological neuron and artificial neuron models. Perceptron and multilayer perceptron (MLP). Backpropagation algorithm and training strategies. Activation functions: sigmoid, tanh, ReLU. Learning paradigms: supervised, unsupervised, and reinforcement learning. Hopfield networks, Radial Basis Function networks, and Self-Organizing Maps (SOM).

Unit 4: Genetic Algorithms (GA)
Fundamentals of genetic algorithms. Genetic representation, population initialization, fitness function. Selection mechanisms: roulette wheel, tournament. Genetic operators: crossover, mutation, and elitism. Convergence and parameter tuning. Applications in function optimization, scheduling, and neural network training.

Unit 5: Hybrid Systems and Applications
Neuro-fuzzy systems: architecture and learning algorithms. Fuzzy-genetic systems and their tuning. Integration of ANN, GA, and fuzzy logic for complex problem solving. Case studies in engineering, robotics, medical diagnosis, and optimization. Introduction to software tools for soft computing: MATLAB Fuzzy Toolbox, Scikit-Fuzzy, TensorFlow.

Text Books:

1. S. N. Sivanandam and S. N. Deepa, *Principles of Soft Computing*, Wiley India.
2. J.-S. R. Jang, C.-T. Sun, and E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Pearson Education.

Reference Books:

1. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley.
2. David E. Goldberg, *Genetic Algorithms in Search, Optimization, and Machine Learning*, Addison-Wesley.

Course Code	BAML603				
Category	Minor				
Course title	Image Processing & Computer Vision				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand fundamental concepts and operations in digital image processing.
2. Apply filtering, enhancement, and segmentation techniques on images.
3. Analyze and extract meaningful features from visual data.
4. Implement classical and deep learning-based computer vision algorithms.
5. Utilize image processing libraries and frameworks for real-world applications.

Unit 1: Fundamentals of Image Processing
Introduction to digital images, imaging systems, and applications. Image representation: spatial and frequency domains. Image sampling and quantization. Image file formats and color models (RGB, HSV, YCbCr, Grayscale). Point operations: image negative, log transformation, power-law transformation, histogram equalization. Image arithmetic and logical operations.

Unit 2: Image Filtering and Enhancement
Spatial filtering: smoothing and sharpening filters. Convolution and correlation. Edge detection techniques: Sobel, Prewitt, Laplacian, Canny. Noise models and reduction techniques: Gaussian, salt & pepper noise. Frequency domain filtering using Fourier Transform and Discrete Cosine Transform (DCT). Image restoration basics and inverse filtering.

Unit 3: Image Segmentation and Morphology
Thresholding: global, local, and Otsu's method. Region-based segmentation: region growing, region splitting and merging. Edge-based segmentation. Morphological operations: erosion, dilation, opening, closing. Connected component labeling. Watershed segmentation. Object detection basics and contour analysis. Introduction to template matching and background subtraction.

Unit 4: Features and Motion Analysis
Feature extraction: corners, edges, blobs. Harris and Shi-Tomasi corner detectors. SIFT, SURF, and ORB descriptors. Image matching and homography. Optical flow and motion estimation techniques: Lucas-Kanade, Horn-Schunck. Epipolar geometry and camera calibration. Stereo vision and depth estimation.

Unit 5: Introduction to Deep Learning in Computer Vision
Basics of convolutional neural networks (CNNs) for image classification and object detection. Transfer learning using pretrained models (e.g., VGG, ResNet). Object detection methods: YOLO, SSD, R-CNN. Semantic and instance segmentation. Overview of OpenCV, PIL, and deep learning libraries (TensorFlow, PyTorch) for vision applications.

Text Books:

1. Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson.
2. Szeliski, Richard. *Computer Vision: Algorithms and Applications*, Springer.

Reference Books:

1. Sonka, Hlavac, Boyle, *Image Processing, Analysis, and Machine Vision*, Cengage Learning.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press.

Course Code	BAML614				
Category	Minor				
Course title	Minor Project				
Scheme & Credits	L	T	P	Credits	Semester VI
	0	0	4	2	
Pre-requisite (if any)	None				

The objective of the Minor Project is to provide students with hands-on experience by engaging them in real-world, application-based projects focused on Artificial Intelligence and Machine Learning. Students are expected to work on practical problems that involve data-driven solutions, model development, and intelligent systems, aligned with the latest trends and technologies in AI & ML — such as predictive analytics, computer vision, natural language processing, or intelligent automation.

Note: The detailed guidelines and report format have been shared in separate documents.

Professional Elective – I

Course Code	BEPE601				
Category	Core				
Course title	Data Mining & Data Warehousing				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the basic concepts, methodologies, and techniques used in data mining.
2. Apply data pre-processing techniques to clean and prepare data for mining tasks.
3. Implement and evaluate classification algorithms such as Decision Trees, Naïve Bayes, k-NN, and Support Vector Machines.
4. Analyze clustering techniques like k-Means, Hierarchical clustering, and DBSCAN for grouping data.
5. Apply association rule mining techniques (e.g., Apriori, FP-Growth) to discover patterns and relationships in large datasets.

Unit 1: Introduction

Definition, Importance, and Scope of Data Mining, Data Warehousing Components, Building a Data Warehouse, Warehouse Database, Mapping the Data Warehouse to a Multiprocessor Architecture, Difference between Database System and Data Warehouse, Multi-Dimensional Data Model, Data Cubes, Stars, Snow Flakes, Fact Constellations, Concept, Knowledge Discovery in Databases (KDD) Process, Data Mining vs. Machine Learning vs. Statistics, Types of Data: Structured, Unstructured, Semi-Structured, Applications of Data Mining in AI/ML

Unit 2: Data Mining

Overview, Motivation, Definition & Functionalities, Data Processing, Form of Data Pre-processing, Data Cleaning: Handling Missing Values, Noisy Data, (Binning, Clustering, Regression, Computer and Human inspection), Inconsistent Data, Data Integration and Transformation. Feature Selection and Extraction. Data Reduction: Data Cube Aggregation, Dimensionality reduction, Data Compression, Numerosity Reduction, Discretization and Concept hierarchy generation, Decision Tree, Data Warehousing and OLAP.

Unit 3: Classification Techniques

Definition, Data Generalization, Analytical Characterization, Analysis of attribute relevance, Mining Class comparisons, Statistical measures in large Databases, Statistical-Based Algorithms: Linear Regression, Logistic Regression, Naïve Bayes Classifier, Bayesian Networks, Hidden Markov Models (HMM), Expectation-Maximization (EM) Algorithm, Principal Component Analysis (PCA), Chi-Square Test / ANOVA / t-Test, Time Series Forecasting (ARIMA, SARIMA), K-Means Clustering (statistically interpreted), Distance-Based Algorithms:, Decision Tree-Based Algorithms(ID3, C4.5), k-Nearest Neighbors (k-NN), , Support Vector Machines (SVM), Model Evaluation: Confusion Matrix, Precision, Recall, F1-Score, ROC.

Unit IV: Clustering Techniques

Introduction, Similarity and Distance Measures, Hierarchical and Partition Algorithms, Distance-Based Algorithms: K-Nearest Neighbours (K-NN), K-Means Clustering, Hierarchical Clustering- CURE and Chameleon, Density Based Methods DBSCAN, OPTICS, Self-Organizing Maps (SOM), Multidimensional Scaling (MDS),Grid Based Methods-STING, CLIQUE. Model Based Method – Statistical Approach, Association rules: Introduction, Large Item sets, Basic Algorithms, Parallel and Distributed Algorithms, Neural Network approach. Decision Tree-Based Algorithms: ID3 (Iterative Dichotomiser 3), C4.5, CART (Classification and Regression Trees), CHAID (Chi-squared Automatic Interaction Detector), Random Forest, Gradient Boosted Trees (e.g., XGBoost, LightGBM, CatBoost), Extra Trees (Extremely Randomized Trees)

Unit V: Association Rule Mining & Advanced Topics

Web Mining, Text Mining, and Spatial Data Mining (Introductory Overview), Data Visualization and Overall Perspective: Aggregation, Historical information, Query Facility, OLAP function and Tools. OLAP Servers, ROLAP, MOLAP, HOLAP, Data Mining interface, Security, Backup and Recovery, Tuning Data Warehouse, Testing Data Warehouse. Warehousing applications and Recent Trends: Types of Warehousing Applications, Web Mining, Spatial Mining and Temporal Mining. Introduction to Big Data & Data Mining Tools (WEKA, Orange, Python Libraries like Scikit-learn, Pandas) Market Basket Analysis, Apriori Algorithm, FP-Growth Algorithm, Interestingness Measures: Support, Confidence, Lift.

Text Books:

1. Alex Berson, Stephen J. Smith “Data Warehousing, Data-Mining & OLAP”, McGrawHil.
2. Mark Humphries, Michael W. Hawkins, Michelle C. Dy, “Data Warehousing: Architecture and Implementation”, Pearson Education.
3. I. Singh, “Data Mining and Warehousing”, Khanna Publishing House.
4. Margaret H. Dunham, S. Sridhar,”Data Mining:Introductory and Advanced Topics” Pearson Education

Reference Books:

1. Ian H. Witten, Eibe Frank, Mark A. Hall “Data Mining: Practical Machine Learning Tools and Techniques" Morgan Kaufmann publication.
2. Mohammed J. Zaki, Wagner Meira Jr. ,"Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press 2014.

Course Code	BEPE602				
Category	Core				
Course title	Introduction to Cognitive Science				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the interdisciplinary foundation of cognitive science.
2. Describe the role of psychology, neuroscience, AI, and linguistics in cognition.
3. Analyze different models and theories of mental processes.
4. Apply cognitive principles to solve real-world problems.
5. Evaluate cognitive architectures and intelligent systems.

Unit 1: Fundamentals of Cognitive Science
Definition and Scope of Cognitive Science, Historical Background and Evolution, Core Disciplines: Psychology, Neuroscience, Artificial Intelligence, Linguistics, Philosophy, Cognitive Processes: Perception, Attention, Memory, Learning, Interdisciplinary Nature of Cognitive Science

Unit 2: Cognitive Psychology
Mental Representations and Information Processing, Models of Memory: Sensory, Short-term, Long-term. Attention Mechanisms and Cognitive Load, Learning Theories: Behaviourism, Constructivism, Connectionism, Cognitive Development: Piaget's Stages.

Unit 3: Neuroscience and the Brain
Brain Structure and Function: Neurons, Synapses, Brain Lobes, Neural Basis of Perception, Emotion, and Decision Making, Brain Imaging Techniques: fMRI, EEG, PET, Neuroplasticity and Cognitive Enhancement, Disorders of Cognition: Dementia, Dyslexia.

Unit 4: Artificial Intelligence and Cognitive Modelling
Role of AI in Simulating Human Thought, Symbolic vs. Sub symbolic AI, Cognitive Architectures: ACT-R, SOAR, Neural Networks and Machine Learning Models of Cognition, Applications: Intelligent Agents, Human-Computer Interaction.

Unit 5: Language, Reasoning, and Problem Solving
Theories of Language Acquisition and Processing, Language and Thought: Sapir-Whorf Hypothesis, Reasoning: Deductive, Inductive, Adductive, Problem Solving and Creativity, Ethical and Philosophical Issues in Cognitive Science

Text Book:

1. Jay Friedenberg & Gordon Silverman "Cognitive Science: An Introduction to the Study of Mind" SAGE Publications.
2. Paul Thagard "Mind: Introduction to Cognitive Science", MIT Press

Reference Book:

1. Michael W. Eysenck and Mark T. Keane "Cognitive Psychology: A Student's Handbook", Psychology Press
2. Robert A. Wilson and Frank C. Keil ,"The MIT Encyclopedia of the Cognitive Sciences (MITECS)", MIT Press

Course Code	BEPE603				
Category	Core				
Course title	Big Data Analytics and Machine Learning				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals of big data and machine learning.
2. Work with big data frameworks like Hadoop and Spark.
3. Apply various machine learning techniques to big data sets.
4. Perform data processing, storage, and analytics on large-scale data.
5. Evaluate machine learning models using appropriate metrics.

Unit 1: Introduction to Big Data
Big Data Overview: Definition, Characteristics (5 V's), Challenges, Traditional vs. Big Data Systems, Data Types and Sources: Structured, Semi-structured, Unstructured, Big Data Lifecycle, Case Studies in Healthcare, E-commerce, Finance

Unit 2: Big Data Processing Frameworks
Hadoop Ecosystem: HDFS, MapReduce, YARN, MapReduce Programming Model, Apache Pig and Hive: Features and Use Cases, Introduction to Apache Spark and its Components, Spark vs Hadoop: Real-Time vs Batch Processing

Unit 3: Data Storage and Management
NoSQL Databases: Key-Value Stores, Document Stores, Column Stores, HBase, Cassandra, and MongoDB Overview, Data Ingestion Tools: Sqoop, Flume, Kafka, Data Cleaning, Integration, and Pre-processing Techniques, Data Lake vs Data Warehouse.

Unit 4: Machine Learning for Big Data
Supervised Learning: Regression, Decision Trees, Random Forests, Unsupervised Learning: Clustering, Dimensionality Reduction, Model Evaluation Techniques: Cross-validation, Confusion Matrix, MLlib in Apache Spark, Distributed Machine Learning Techniques.

Unit 5: Applications and Trends in Big Data and ML
Real-World Applications: Fraud Detection, Recommendation Systems, AI Integration with Big Data, Cloud Platforms for Big Data Analytics: AWS, Azure, Google Cloud, Data Ethics and Governance, Trends: AutoML, Federated Learning, Real-time Analytics.

Text Book:

1. Jared Dean ,"Big Data and Machine Learning", Wiley
2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann
3. Aurélien Géron ,"Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow", O'Reilly Media

Reference Book:

1. Tom M. Mitchell, "Machine Learning", McGraw Hill
2. Jure Leskovec, Anand Rajaraman, and Jeffrey Ullman, "Mining of Massive Datasets" Cambridge University Press.
3. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", EMC Education Services

Course Code	BEPE604				
Category	Core				
Course title	AI in Internet of Things (IoT)				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	1	0	4	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the architecture and components of IoT systems.
2. Explain the integration of Artificial Intelligence (AI) techniques in IoT systems.
3. Apply machine learning models for IoT data analysis.
4. Analyze edge and fog computing models in AIoT systems.
5. Design AI-powered IoT applications for real-world problems.

Unit 1: Introduction to IoT and AI

Basics of IoT: Definitions, Architecture, Components (Sensors, Actuators, Gateways),IoT Communication Protocols: MQTT, CoAP, HTTP, Overview of Artificial Intelligence: Definitions and Scope, Convergence of AI and IoT: Concept of AIoT, Opportunities and Challenges, Applications of AIoT: Smart cities, Smart homes, Smart agriculture, Industry 4.0

Unit 2: Data Acquisition and Pre-processing in IoT

IoT Data Sources and Types (Structured, Semi-structured, Unstructured),Data Pre-processing Techniques: Cleaning, Transformation, Normalization, Real-time vs Batch Data Processing, Sensor Data Characteristics and Challenges, Use Cases: Health monitoring, Environmental monitoring.

Unit 3: Machine Learning Techniques for IoT

Supervised Learning for IoT: Regression, Decision Trees, SVM, and Unsupervised Learning: Clustering (K-Means, DBSCAN), PCA, Time Series Forecasting in IoT, Model Evaluation Metrics: Accuracy, Precision, Recall, F1 Score, and Tools: Scikit-learn, TensorFlow Lite, and Edge Impulse.

Unit 4: Edge AI and Fog Computing

Limitations of Cloud-based IoT, Concepts of Edge and Fog Computing, Edge AI: Introduction, Use-cases, and Architectures, Edge AI Hardware: NVIDIA Jetson, Raspberry Pi, Google Coral, Lightweight AI Models: TinyML, Pruned and Quantized Models.

Unit 5: AIoT Applications and Security

AI-powered IoT Applications: Predictive Maintenance, Anomaly Detection, Intelligent Transportation Systems, Smart Energy Management, Privacy and Security Issues in AIoT Systems, Secure Data Transmission and Blockchain Integration, Ethical Issues and Governance in AIoT

Text Book:

1. Rajiv Pandey, Ajesh Babu, Brojo Kishore Mishra ," Artificial Intelligence and Internet of Things (AIoT): Applications, Challenges, and Opportunities" CRC Press / Taylor & Francis
2. Rajkumar Buyya, Amir Vahid Dastjerdi, "Internet of Things: Principles and Paradigms" Morgan Kaufmann, 2016

Reference Books:

1. Rajesh Singh, Anita Gehlot, "Internet of Things with Raspberry Pi and Arduino: Practical Experiments" CRC Press, 2020.
2. William Lawless, Ranjeev Mittu, Donald Sofge , "Artificial Intelligence for the Internet of Everything", Academic Press / Elsevier,2021

Professional Elective – II

Course Code	BEPE605				
Category	Minor				
Course title	Deep Learning Architectures				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs): At the end of the course, the student will be able:

1. Understand the fundamentals of deep learning techniques, neural networks, and the mathematical foundations underlying deep learning models.
2. Design, implement, and analyze various deep learning architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformer models.
3. Apply deep learning techniques to real-world problems in areas like computer vision, natural language processing, and time-series analysis.
4. Evaluate deep learning models using appropriate performance metrics and optimize them through techniques like regularization, hyper parameter tuning, and model compression.
5. Demonstrate proficiency in utilizing deep learning frameworks and libraries such as TensorFlow, Keras, and PyTorch for building scalable AI solutions.

Unit 1: Introduction to Deep Learning
Difference between Machine Learning and Deep Learning, Neural Networks: Biological and Artificial Neurons, Activation Functions: Sigmoid, Tanh, ReLU, Softmax, Gradient Descent and Back-propagation, Overfitting, Underfitting, and Regularization (Dropout, L1/L2)

Unit 2: Feed forward Neural Networks
Architecture of a Multi-layer Perceptron (MLP), Forward and Backward Pass Computation, Loss Functions: Cross-Entropy, MSE, Optimizers: SGD, Adam, RMSProp, and Implementation with TensorFlow/Keras or PyTorch

Unit 3: Convolution Neural Networks (CNNs)
Convolution Operation and Feature Maps, Pooling Layers (Max, Average), Padding, Stride, Popular CNN Architectures: LeNet, Alex Net, VGG, ResNet, Image Classification and Object Detection Tasks, Transfer Learning and Fine-tuning Pertained Models

Unit 4: Recurrent Neural Networks (RNNs) and Sequence Models
RNNs and their Challenges: Vanishing Gradients, Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRUs), Applications: Text Generation, Language Modelling, Speech Recognition, Attention Mechanism and Introduction to Transformers, Sequence-to-Sequence Models

Unit 5: Advanced Deep Learning Architectures
Generative Adversarial Networks (GANs): Architecture, Training, Use Cases, Autoencoders: Variational Autoencoders (VAE), Denoising Autoencoders, Transformer Architecture and BERT Overview, Deployment of Deep Learning Models (Edge, Cloud), Ethical Considerations and Interpretability in Deep Learning

Text Book:

1. Ian Good fellow, Yoshua Bengio, and Aaron Courville, "Deep Learning", MIT Press
2. Ian Pointer, "Programming PyTorch for Deep Learning", O'Reilly Media

Reference Book:

1. Charu C. Aggarwal ,"Neural Networks and Deep Learning: A Textbook", Springer
2. Yuxi (Hayden) Liu ,"Hands-On Deep Learning Architectures with Python", Packt Publishing

Course Code	BEPE606				
Category	Minor				
Course title	Explainable AI (XAI)				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the need for explain ability in AI systems.
2. Explore key concepts, techniques, and frameworks of XAI.
3. Apply model-specific and model-agnostic methods for interpretability.
4. Evaluate trade-offs between performance and explain ability.
5. Design transparent and accountable AI applications for critical domains.

Unit 1: Introduction to Explainable AI
Motivation for XAI: Trust, Fairness, Ethics, Accountability, Black-box vs. White-box Models, Human-Centered AI: Interpretability vs. Explainability, AI Bias and Fairness Issues, Overview of Regulatory Compliance (GDPR, AI Act)

Unit 2: Interpretable Models
Simple and Transparent Models: Decision Trees, Linear Regression, Rule-based Systems, Visualization Techniques for Interpretability, Case Studies: Credit Scoring, Loan ,Approval, Medical Diagnosis, Limitations of Interpretable Models, Accuracy vs Interpretability Trade-offs

Unit 3: Post-hoc Explainability Methods
Model-Agnostic Techniques: LIME (Local Interpretable Model-Agnostic Explanations),SHAP (SHapley Additive explanations),Feature Importance and Permutation Methods, Saliency Maps and Grad-CAM (for Deep Learning),Explanation Fidelity, Stability, and Consistency

Unit 4: Explainability in Deep Learning and NLP
Explainability in Neural Networks and CNNs, Visual Explanations for Image Models, Attention Mechanism and Interpretability in Transformers (e.g., BERT),XAI in Natural Language Processing, Case Studies: XAI in Healthcare, Autonomous Vehicles, Defense.

Unit 5: Tools, Frameworks, and Challenges
XAI Libraries: LIME, SHAP, ELI5, Captum, IBM AI Explainability 360,Evaluation Metrics for Explanations, Human Factors in XAI: Usability, Trust, Decision Support, Challenges in Scaling XAI in Industry, Future Trends: Causal XAI, Interactive XAI, Regulatory XAI\

Text Book:

1. Christoph Molnar, "Interpretable Machine Learning", Self-Published, 2nd Edition, 2022
2. Ankur Taly, Klaus-Robert Müller,Wojciech Samek, "Explainable AI: Interpreting, Explaining and Visualizing Deep Learning", Springer, 1st Edition, 2019
3. David Gunning, Andreas Holzinger, "XAI – Explainable Artificial Intelligence: A Guide for Transparency in AI", Springer, 1st Edition, 2023

Reference Book:

1. Wojciech Samek, Thomas Wiegand, Klaus-Robert Müller, "Explainable AI: Interpreting, Explaining and Visualizing Deep Learning", Springer, 1st Edition, 2019
2. Daniele Magazzeni, Tim Miller, Berkay Yilmaz, "Advances in Explainable Artificial Intelligence: Concepts, Algorithms, and Applications", Springer, 1st Edition, 2022
3. Rashmi Agrawal, Meenu Gupta, Neha Gupta, "Explainable AI: A Perspective for Academia and Industry", CRC Press, 1st Edition, 2021

Course Code	BEPE607				
Category	Minor				
Course title	AI Ethics and Governance				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the ethical and societal implications of AI.
2. Analyze fairness, accountability, and transparency in AI systems.
3. Explore frameworks and laws governing AI use.
4. Apply responsible AI practices in real-world contexts.
5. Critically assess case studies of AI failures and design ethical AI solutions.

Unit 1: Introduction to AI Ethics
Overview of Ethics in Artificial Intelligence, Key Ethical Principles: Fairness, Non-maleficence, Responsibility, Moral Dilemmas in AI Applications, Historical AI Failures and Biases, Importance of Trustworthy and Responsible AI.

Unit 2: Bias, Fairness, and Discrimination in AI
Sources of Bias in Data and Algorithms, Fairness Metrics: Equal Opportunity, Demographic Parity, Equalized Odds, Case Studies: Facial Recognition, Hiring Algorithms, Predictive Policing, Techniques for Bias Mitigation, Inter-sectionality and Ethical Challenges in Diverse Populations

Unit 3: Accountability and Transparency
Explainability and Interpretability as Ethical Requirements, Black-Box AI and the Right to Explanation,AI Auditing and Governance Mechanisms, Algorithmic Accountability and Redress, Stakeholders in AI Ecosystems: Developers, Users, Regulators

Unit 4: Legal, Policy, and Global Governance
AI Policies and Guidelines (IEEE, OECD, UNESCO, EU AI Act),Privacy and Data Protection Laws (GDPR, India DPDP Act 2023)Global Perspectives on Regulating AI, Challenges in Cross-border AI Governance, National AI Strategies (India, USA, EU, China)

Unit 5: Future of Ethical and Regulated AI
Ethical Challenges in Emerging Technologies: Autonomous Vehicles, Deepfakes, Surveillance, Human-in-the-Loop and AI Alignment, Designing Ethical AI Systems, AI for Social Good and Sustainable Development Goals (SDGs), Ethical AI Startups and Innovation Ecosystem

Text Book:

1. Mark Coeckelbergh, "AI Ethics", MIT Press, 1st Edition, 2020
2. Wendell Wallach and Colin Allen, "Moral Machines: Teaching Robots Right from Wrong", Oxford University Press, 1st Edition, 2008
3. Francis X. Govers, "Artificial Intelligence and Ethics: An Emerging Area of Study", CRC Press, 1st Edition, 2021

Reference Book:

1. Toby Walsh, "Machines Behaving Badly: The Morality of AI", Prometheus Books, 1st Edition, 2022
2. John C. Havens, "Heartificial Intelligence: Embracing Our Humanity to Maximize Machines", TarcherPerigee (Penguin), 1st Edition, 2016
3. Virginia Dignum, "Responsible Artificial Intelligence: How to Develop and Use AI in a
4. Responsible Way", Springer, 1st Edition, 2019

Course Code	BEPE608				
Category	Minor				
Course title	Quantum Computing for AI				
Scheme & Credits	L	T	P	Credits	Semester VI
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles of quantum mechanics relevant to computing.
2. Explore quantum computing models and their application to AI.
3. Analyze quantum algorithms for AI and machine learning tasks.
4. Evaluate the limitations and possibilities of quantum-enhanced AI.
5. Use basic tools and simulators to implement quantum-AI models.

Unit 1: Fundamentals of Quantum Computing
Classical vs Quantum Computing, Basic Concepts: Qubits, Superposition, Entanglement, Quantum Gates and Circuits: Pauli Gates, Hadamard, CNOT, Quantum Measurement and Collapse, Quantum Programming Languages: Qiskit, Cirq

Unit 2: Quantum Algorithms and Complexity
Quantum Parallelism, Deutsch-Jozsa Algorithm, Grover's Search Algorithm and its AI Relevance, Shor's Algorithm and Cryptography, Quantum vs Classical Complexity Classes (P, NP, BQP)

Unit 3: Quantum Machine Learning (QML)
Introduction to Quantum Machine Learning, Hybrid Quantum-Classical Models, Variational Quantum Circuits (VQC) and QAOA, Quantum-enhanced Supervised and Unsupervised Learning, Frameworks: PennyLane, TensorFlow Quantum

Unit 4: Quantum AI Applications
Quantum-enhanced Data Clustering and Classification, Quantum Neural Networks (QNNs),Quantum Natural Language Processing (QNLP),Quantum AI in Optimization and Reinforcement Learning,Case Studies: Quantum AI in Drug Discovery, Finance, and Cryptography

Unit 5: Challenges, Ethics, and Future Trends
Current Hardware Limitations: Decoherence, Qubit Noise, Ethical Concerns in Quantum AI: Security, Control, Dual Use, Simulation Platforms vs Real Quantum Computers, Future of Quantum Supremacy and AI Synergy, Global Initiatives: IBM Q, Google Sycamore, India's National Quantum Mission.

Text Book:

1. Michael A. Nielsen and Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 10th Anniversary Edition, 2010
2. Mikio Nakahara and Tetsuo Ohmi, "Quantum Computing: From Linear Algebra to Physical Realizations", CRC Press, 2nd Edition, 2008
3. Eleanor G. Rieffel and Wolfgang H. Polak, "Quantum Computing: A Gentle Introduction", MIT Press, 1st Edition, 2011

Reference Book:

1. Salvador E. Venegas-Andraca, "Quantum Computing for Computer Scientists", Springer, 1st Edition, 2008
2. Christof Zalka, "Quantum Computing: An Applied Approach", Springer, 1st Edition, 2020
3. Hans De Raedt, Kristel Michielsen, "Computational Methods for Simulating Quantum Computers", Morgan & Claypool Publishers, 1st Edition, 2019

Open Elective – II

Course Code	BEOE601				
Category	Open Elective				
Course title	Innovation and Startup Management				
Scheme & Credits	L	T	P	Credits	Semester VI
	2	0	0	2	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles of innovation and entrepreneurship in the context of the technology industry.
2. Identify opportunities and challenges in launching startups, especially in AI/ML and tech-driven domains.
3. Develop and evaluate business models, startup strategies, and value propositions.
4. Gain insights into funding mechanisms, incubators, accelerators, and legal aspects of startups.
5. Apply design thinking and innovation frameworks to create sustainable and scalable AI-based products/services.

Unit I: Innovation, Ideation, and Entrepreneurship Foundations
Definition and Types of Innovation, Innovation vs. Invention, Role of AI/ML in Disruptive Innovation, Entrepreneurship: Types, Characteristics, and Functions, Innovation-Driven Entrepreneurship in Tech Sector Problem Identification and Ideation Techniques, Design Thinking for Innovation, Opportunity Recognition and Market Research, AI-Based Product Ideas: Case Studies, Validation and Feasibility Analysis

Unit II: Business Planning, Modelling, and Financing
Business Model Canvas, Value Proposition and Customer Segments, Revenue Models, Cost Structure, and Key Resources, MVP (Minimum Viable Product) Development, Lean Startup Methodology, Funding Stages: Bootstrapping, Angel Investment, Venture Capital, Role of Incubators and Accelerators, Pitching and Fundraising Strategies, Financial Planning and ROI, Growth Hacking and Scaling Strategies

Unit III: Legal, Ethical, and Strategic Aspects of Startups
Legal Formalities and IP (Patents, Copyright, Trademark), Company Registration and Compliance, Ethics in Entrepreneurship, Startup Failures: Causes and Learning, Case Studies of Successful AI/ML Startups

Textbooks

1. Ramesh Babu, "Innovation and Entrepreneurship", Himalaya Publishing House, 1st Edition, 2019.
2. Peter F. Drucker, "Innovation and Entrepreneurship", Harper Business, Revised Edition, 2006.
3. Narayana Murthy, "Management and Entrepreneurship", IK International Publishing House, 1st Edition, 2010.

Reference Books

1. Eric Ries, "The Lean Startup", Crown Business, 1st Edition, 2011.
2. Steve Blank and Bob Dorf, "The Startup Owner's Manual", K&S Ranch, 1st Edition, 2012.
3. Alex Osterwalder & Yves Pigneur, "Business Model Generation", Wiley, 1st Edition, 2010.

Course Code	BEOE602				
Category	Open Elective				
Course title	Innovation and Intellectual Property				
Scheme & Credits	L	T	P	Credits	Semester VI
	2	0	0	2	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the nature and significance of innovation in technology-based environments.
2. Identify and differentiate between various types of Intellectual Property Rights (IPRs).
3. Apply procedures for patent filing, copyright registration, and trademark protection.
4. Analyze the role of IPR in protecting AI/ML-driven innovations and startups.
5. Evaluate case studies and legal frameworks related to innovation, patents, and commercialization.

Unit I: Innovation, Creativity, and Intellectual Property Fundamentals

Introduction to Innovation: Types and Process, Creativity and Problem Solving in AI Product Design, Role of Innovation in Economic Development, Innovation Strategies in AI/ML and Startups, Disruptive vs. Incremental Innovation, Introduction to IPR and its Importance, Categories of IPR: Patents, Copyrights, Trademarks, Trade Secrets, International IP System (WIPO, TRIPS), IP in Software and Artificial Intelligence AI-generated Content and Legal Implications

Unit II: Patent System and AI-specific IP Challenges

Meaning and Criteria of Patentability, Types of Patents: Utility, Design, Plant, Patent Filing Procedure in India and Globally, Patent Search, Drafting, and Infringement Issues, AI and Patentability Challenges, Copyrights: Protection for Software, Datasets, and AI Content, Trademarks: Brand Identity and Protection, Industrial Designs: Registration and Protection, Geographical Indications and Trade Secrets, Case Studies: IPR in AI-based Products

Unit III: IP Management, Commercialization, and Legal Ethics

Licensing and Technology Transfer, IP Valuation and Monetization Strategies, Startups and IPR Strategy, IP Enforcement and Dispute Resolution, Ethical and Legal Issues in AI and IPR

Textbooks

1. Neeraj Pandey & Khushdeep Dharni, "Intellectual Property Rights", PHI Learning, 1st Edition, 2014.
2. R. Radha Krishnan & S. Balasubramanian, "Intellectual Property Rights", Excel Books, 1st Edition, 2008.
3. Kankanala Kalyan C., "Fundamentals of Intellectual Property", Asia Law House, 1st Edition, 2012.

Reference Books

1. Prabuddha Ganguli, "Intellectual Property Rights: Unleashing the Knowledge Economy", Tata McGraw Hill, 1st Edition, 2001.
2. WIPO, "WIPO Intellectual Property Handbook", WIPO Publication, 2nd Edition, 2020.
3. Deborah E. Bouchoux, "Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets", Cengage Learning, 5th Edition, 2019.

Course Code	BEOE603				
Category	Open Elective				
Course title	Design Thinking for Engineers				
Scheme & Credits	L	T	P	Credits	Semester VI
	2	0	0	2	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the core concepts and importance of design thinking in engineering innovation.
2. Apply empathy and user-centric methods to identify real-world problems and user needs.
3. Use ideation techniques to generate innovative and viable AI/ML-based solutions.
4. Develop low and high-fidelity prototypes and validate them through iterative testing.
5. Apply the design thinking process to real-life problems using interdisciplinary teamwork and AI tools.

Unit I: Foundations of Design Thinking and Empathy in AI

What is Design Thinking, Evolution and Importance in Engineering & AI, Design Thinking vs. Traditional Problem Solving, Design Thinking Process Overview: Empathize, Define, Ideate, Prototype, Test Design Thinking Mindset, User-Centered Design, Empathy Mapping and Field Research, User Interviews and Observation, Identifying Pain Points and Needs, AI Tools in Empathy and Research

Unit II: Problem Definition, Ideation, and Team Creativity

Problem Definition Techniques, Crafting Problem Statements (POV Statements, HMW Questions), Ideation Techniques: Brainstorming, SCAMPER, Mind Mapping, Convergent vs. Divergent Thinking, Group Ideation and Creativity in Teams, Importance of Prototyping, Low-Fidelity vs. High-Fidelity Prototypes, Tools for Prototyping (AI/ML mockups, Wireframes, Simulation Tools), User Testing and Feedback Collection, Iterative Design and Agile Thinking

Unit III: Design Thinking Applications in AI, Engineering, and Society

Case Studies in AI/ML, Product Design, and Smart Systems, Design Thinking for Social Innovation and Startups, Integration with Lean and Agile Methodologies, Ethics in Human-Centered AI Design, Final Capstone Project: AI/ML-based Solution Development Using Design Thinking,

Textbooks

1. Tim Brown, "Change by Design", Harper Business, 1st Edition, 2009.
2. Nigel Cross, "Design Thinking: Understanding How Designers Think and Work", Bloomsbury Academic, 1st Edition, 2011.
3. Peter G. Rowe, "Design Thinking", MIT Press, Reprint Edition, 1991.

Reference Books

1. Jeanne Liedtka, Tim Ogilvie, "Designing for Growth: A Design Thinking Tool Kit for Managers", Columbia Business School Publishing, 1st Edition, 2011.
2. David Kelley & Tom Kelley, "Creative Confidence: Unleashing the Creative Potential Within Us All", Crown Business, 1st Edition, 2013.
3. Rolf Faste, "Design Thinking: From Product Innovation to Societal Problem Solving", Springer, 1st

Course Code	BEOE604				
Category	Open Elective				
Course title	Sustainable Technology & Development				
Scheme & Credits	L	T	P	Credits	Semester VI
	2	0	0	2	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles of sustainability and their application in technology and development.
2. Analyze the environmental, economic, and social impacts of technology in AI/ML-driven systems.
3. Explore sustainable practices in energy, transportation, agriculture, and smart city planning.
4. Apply AI/ML in building sustainable solutions for resource optimization and environmental monitoring.
5. Evaluate government policies, global initiatives, and ethical dimensions related to sustainable development.

Unit I: Foundations of Sustainability and Technological Integration

Concept of Sustainability, Sustainable Development Goals (SDGs), Interrelationship between Technology and Sustainable Development, Systems Thinking and Life Cycle Analysis, Role of Engineers and Technologists in Sustainable Growth, Environmental Degradation and Technological Solutions, Waste Management Renewable vs. Non-renewable Resources, Carbon Footprint and Climate Change, Social Equity and Inclusion in Technology, Ethics in Sustainable AI Development

Unit II: Sustainable and Green Technologies

Renewable Energy Technologies: Solar, Wind, Bio-energy, Water Conservation and Waste Management, Green Building and Sustainable Infrastructure, Circular Economy and Resource Efficiency, CleanTech and Green Computing, AI Applications in Energy Optimization, Smart Grids, Precision Agriculture using ML, Smart Cities: Waste, Water, and Traffic Management, Climate Prediction and Environmental Monitoring with AI, Case Studies on AI-Driven Sustainability

Unit III: Policy, Innovation, and the Future of Sustainable Tech

Government Policies and Incentives for Sustainable Technology, National Action Plan on Climate Change (NAPCC), Global Sustainability Initiatives (Paris Agreement, UN SDGs), Sustainable Entrepreneurship and Green Innovation, Future Trends and Careers in Sustainable Tech

Textbooks

1. Katar Singh & Anil Shishodia, "Environmental Economics and Development", Oxford University Press, 2nd Edition, 2007.
2. M. A. Maleki, "Sustainable Development and Engineering: Concepts, Design and Case Studies", Springer, 1st Edition, 2020.
3. R. K. Pachauri, "Sustainable Development: Issues and Challenges", TERI Press, 1st Edition, 2010.

Reference Books

1. Geoffrey Boyle, "Renewable Energy: Power for a Sustainable Future", Oxford University Press, 3rd Edition, 2012.
2. Jeffrey Sachs, "The Age of Sustainable Development", Columbia University Press, 1st Edition, 2015.
3. Peter Rogers, Kazi Jalal, John Boyd, "An Introduction to Sustainable Development", Earthscan Publications, 2nd Edition, 2008.

Semester VII

Detailed Fourth Year Curriculum Contents

Course Code	BAML701				
Category	Core				
Course title	Natural Language Processing				
Scheme & Credits	L	T	P	Credits	Semester
	3	1	0	4	VII
Pre-requisite (if any)	Deep learning fundamentals, Python and basic ML understanding				

Course Outcomes (COs):

1. Understand and apply text processing techniques.
2. Implement DL models for NLP tasks.
3. Fine-tune transformer-based architectures.
4. Evaluate NLP model accuracy and performance.
5. Design NLP-based real-world solutions.

Unit I: Introduction to NLP and Text Processing
NLP tasks and applications, Tokenization, stemming, lemmatization, Stop word removal, POS tagging, Hands-on: Building a simple text cleaner pipeline,

Unit II: Text Representation Techniques
Bag of Words, TF-IDF, Word embeddings: Word2Vec, GloVe, FastText, Vector similarity and distance metrics Hands-on: Document similarity and keyword extraction

Unit III: Sequence Models and LSTM-based Architectures
RNNs, LSTMs and GRUs in NLP, Sequence labeling, tagging problems Sentiment classification with LSTM, Hands-on: Sequence modeling for tweets/reviews

Unit IV: Transformers and Advanced NLP
Introduction to Attention and Transformer, Using BERT and Hugging Face models, Fine-tuning transformers for downstream tasks Hands-on: Text classification using BERT

Unit V: Fine-Tuning Techniques and NLP Applications
Fine-tuning techniques for Large Language Models (LLMs), including supervised tuning and lightweight methods like LoRA.
Chatbot building, Text summarization and Q&A systems, Machine translation basics, Hands-on: Complete NLP pipeline project

Text Book(s):

1. Natural Language Processing with Python – Bird, Klein, Loper
2. Deep Learning for NLP – Palash Goyal et al.
3. Transformers for NLP – Denis Rothman

Course Code	BAML702				
Category	Minor				
Course title	AI Model Deployment, MLOps & Industry Applications				
Scheme & Credits	L	T	P	Credits	Semester
	3	1	0	4	VII
Pre-requisite (if any)	Familiarity with ML/DL workflows, Python and basic web development knowledge				

Course Outcomes (COs):

1. Understand deployment architecture and strategies.
2. Build and serve ML models using APIs.
3. Use MLOps tools for reproducible pipelines.
4. Deploy containerized ML solutions.
5. Deliver production-ready AI applications

Unit I: Deployment Concepts and APIs

Introduction to model serving and inference, REST APIs with Flask and FastAPI , Deploying ML models with Streamlit, Hands-on: Creating and deploying prediction APIs

Unit II: MLOps and CI/CD Pipelines

Introduction to MLOps lifecycle, MLFlow for experiment tracking, DVC for data and model versioning, GitHub Actions and CI/CD workflows, Hands-on: MLOps flow for sample project

Unit III: Containerization and Cloud Deployment

Docker basics: image, container, Dockerfile, Dockerizing ML models, deploying with Streamlit + Docker Introduction to cloud platforms (AWS/GCP basics), Hands-on: Deploy a model using Docker locally or to Heroku

Unit IV: Real-world ML Applications

Domain-specific examples: e-commerce, finance, healthcare, End-to-end pipeline (data → model → deployment), Logging and monitoring (basic), Hands-on: Full pipeline from notebook to app

Unit V: Industry Project and Presentation

Build, deploy, and present a complete ML app, Team collaboration via Git, CI/CD integrated delivery, Hands-on: Industry use-case deployment

Text Book(s):

1. Building Machine Learning Pipelines – Hannes Hapke, Catherine Nelson
2. Machine Learning Engineering – Andriy Burkov
3. MLOps Guide – mlops.community

Course Code	BCSE721				
Category	Value Added				
Course title	Industrial Interaction				
Scheme & Credits	L	T	P	Credits	Semester
	0	0	4	4	VII
Pre-requisite (if any)	NA				

To provide students with real-world exposure through summer training after the 5th semester, enabling them to connect academic knowledge with industry practices.
In the 6th semester, students are required to present their training experience and undergo evaluation based on their presentation, report, and industry feedback.
Note: Detailed curriculum and guidelines are available at the following link:

https://drive.google.com/file/d/1eiJkMBxTzbhCnI6yGkMceuRSiAKThYT7/view?usp=sharing

Course Code	BAML712				
Category	Core				
Course title	Capstone Project				
Scheme & Credits	L	T	P	Credits	Semester
	0	0	12	6	VII
Pre-requisite (if any)	NA				

To enable students to apply theoretical knowledge to real-world problems by developing innovative AI & ML-based solutions. The Capstone Project encourages independent research, teamwork, and the practical application of machine learning, deep learning, or AI techniques.

Students will be evaluated based on project proposal, implementation, documentation, and final presentation.

Note: Guidelines and report format are shared in a separate document.

Professional Elective –III

Course Code	BEPE701				
Category	Core				
Course title	Generative AI				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles and architectures behind generative models.
2. Explore applications of generative AI in image, text, and audio synthesis.
3. Apply and train models like GANs, VAEs, and Transformers.
4. Evaluate the quality of generated content using standard metrics.
5. Analyze ethical and societal implications of generative AI technologies.

Unit 1: Introduction to Generative AI
Definition and Evolution of Generative AI, Types of Learning: Discriminative vs Generative, Applications: Text Generation, Image Synthesis, Code Completion, Music Generation, Generative Modelling Techniques: Probabilistic and Neural Approaches, Overview of Deep Generative Models: VAEs, GANs, Diffusion Models

Unit 2: Variational Autoencoders (VAEs)
Autoencoders: Architecture and Training, Variational Autoencoders: Latent Space, KL Divergence, Sampling and Reconstruction, Conditional VAEs for Label-guided Generation, Applications: Anomaly Detection, Face Generation.

Unit 3: Generative Adversarial Networks (GANs)
GAN Architecture: Generator, Discriminator, Adversarial Training, Training Challenges: Mode Collapse, Non-convergence, DCGAN, StyleGAN, CycleGAN, Pix2Pix, Conditional GANs and Text-to-Image Generation, Evaluation Metrics: Inception Score (IS), Frechet Inception Distance (FID).

Unit 4: Generative Transformers and LLMs
Sequence Modelling with Transformers, Language Models: GPT, BERT, T5, and Beyond, Text Generation and Completion, Prompt Engineering and Few-shot Learning, Large Language Models (LLMs) for Image, Audio, and Code Generation.

Unit 5: Ethics, Regulation, and Future Trends
Deepfakes, Misinformation, and Content Authenticity, Copyright, Intellectual Property, and Fair Use, Responsible Deployment of Generative Models, Explainability in Generative AI, Trends: Multimodal Models (e.g., DALL•E, Gemini, Sora), Diffusion Models.

Text Book(s):

1. David Foster, "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play", O'Reilly Media, 2nd Edition, 2022
2. Sebastian Raschka, Yuxi (Hayden) Liu, "Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python", Packt Publishing, 2nd Edition, 2022
3. Andreas Braun, Anurag Bhardwaj, "Practical Generative AI: Getting Started with Generative Models Using PyTorch", Apress, 1st Edition, 2024

Reference Book:

1. Jakob Aungiers, "Hands-On Generative AI with OpenAI and ChatGPT: Build Next-Gen Apps with ChatGPT API and GPT-4", Packt Publishing, 1st Edition, 2023
2. Denis Rothman, "Transformers for Natural Language Processing", Packt Publishing, 2nd Edition, 2022

Course Code	BEPE702				
Category	Core				
Course title	Reinforcement Learning				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the core concepts of reinforcement learning (RL).
2. Formulate problems as Markov Decision Processes (MDPs).
3. Apply value-based and policy-based RL algorithms.
4. Explore deep reinforcement learning techniques for real-world applications.
5. Analyze the challenges and limitations of RL systems.

Unit 1: Introduction to Reinforcement Learning
Basics of Reinforcement Learning, Types of Learning: Supervised, Unsupervised, Reinforcement, Agent, Environment, Actions, States, Rewards, Exploration vs Exploitation, Applications of RL: Robotics, Game Playing, Finance, and Healthcare.

Unit 2: Markov Decision Processes (MDPs)
MDP Framework: States, Actions, Transition Probabilities, Rewards, Bellman Equations: Value Function and Optimality, Policy, Value Function, Q-function, Finite and Infinite Horizon Problems, Dynamic Programming: Policy Evaluation, Policy Iteration, Value Iteration

Unit 3: Model-Free Prediction and Control
Monte Carlo Methods: First-Visit and Every-Visit, Temporal Difference (TD) Learning, SARSA (State-Action-Reward-State-Action), Q-Learning Algorithm, Eligibility Traces and TD(λ)

Unit 4: Policy Gradient and Deep Reinforcement Learning
Limitations of Value-based Methods, Policy Gradient Methods: REINFORCE Algorithm, Actor-Critic Architecture, Introduction to Deep Q-Networks (DQN), Advanced Architectures: A3C, PPO, DDPG, SAC.

Unit 5: Case Studies and Challenges
RL in Real-time Strategy Games and Simulations, Multi-agent Reinforcement Learning, Sample Efficiency and Generalization, Safety, Stability, and Interpretability in RL, Tools and Frameworks: OpenAI Gym, Tensor Flow Agents, RLlib.

Text Book:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", MIT Press, 2nd Edition, 2018
2. Csaba Szepesvári, "Algorithms for Reinforcement Learning", Morgan & Claypool Publishers, 1st Edition, 2010
3. Laura Graesser and Wah Loon Keng, "Foundations of Deep Reinforcement Learning: Theory and Practice in Python", Addison-Wesley, 1st Edition, 2019

Reference Book:

1. Maxim Lapan, "Deep Reinforcement Learning Hands-On", Packt Publishing, 2nd Edition, 2020
2. Yuxi (Hayden) Liu, "Reinforcement Learning: An Introduction to Policy Gradient Methods", Independently Published, 1st Edition, 2019
3. Alexander Zai and Brandon Brown, "Deep Reinforcement Learning in Action", Manning Publications, 1st Edition, 2020

Course Code	BEPE703				
Category	Core				
Course title	Multi-Agent Systems				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamental principles of multi-agent systems (MAS).
2. Analyze agent communication, cooperation, and coordination mechanisms.
3. Apply game-theoretic and decision-making models to MAS.
4. Develop models for distributed problem solving and negotiation.
5. Explore real-world applications of MAS in robotics, AI, and IoT.

Unit 1: Introduction to Multi-Agent Systems
Definition and Scope of Multi-Agent Systems, Characteristics of Agents and Environments, Types of Agents: Reactive, Deliberative, Hybrid, Applications of MAS: Robotics, Smart Grid, E-Commerce, Logistics, Agent Architectures: BDI, Subsumption.

Unit 2: Agent Communication and Interaction
Agent Communication Languages (ACLs): KQML, FIPA-ACL, Ontology's and Semantic Interoperability, Communication Protocols and Speech Act Theory, Coordination and Cooperation Strategies, Blackboard and Contract Net Models

Unit 3: Distributed Problem Solving
Task Allocation and Resource Sharing, Distributed Planning and Scheduling, Coalition Formation and Teamwork, Distributed Constraint Satisfaction Problems (DCSPs), Multi-Agent Reinforcement Learning Basics.

Unit 4: Game Theory and Decision Making in MAS
Introduction to Game Theory in MAS, Strategic Games, Nash Equilibrium, Cooperative vs Non-Cooperative Games, Mechanism Design, Auctions, and Voting Protocols, Bargaining, Negotiation, and Fairness.

Unit 5: Applications and Advanced Topics
MAS in Smart Transportation and Traffic Control, MAS for Internet of Things (IoT) and Edge Computing, Swarm Intelligence and Emergent Behavior, Security and Trust in MAS, Tools and Platforms: JADE, NetLogo, MASON

Text Book:

1. Gerhard Weiss, "Multi-agent Systems: A Modern Approach to Distributed Artificial Intelligence", MIT Press, 1st Edition, 1999
2. Yoav Shoham and Kevin Leyton-Brown, "Multi-agent Systems: Algorithmic, Game-Theoretic, and Logical Foundations", Cambridge University Press, 1st Edition, 2009
3. Michael Wooldridge, "An Introduction to Multi-Agent Systems", Wiley, 2nd Edition, 2009

Reference Book:

1. Stefan Voigt, "Multi-Agent Systems: Simulation and Applications", CRC Press, 1st Edition, 2010
2. Franziska Klügl and Sascha Ossowski, "Coordination of Internet Agents: Models, Technologies, and Applications", Springer, 1st Edition, 2003
3. Nikolaos M. Freris, "Distributed Algorithms for Message-Passing Systems", Springer, 1st Edition, 2021

Course Code	BEPE704				
Category	Core				
Course title	Blockchain and AI & ML				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals of blockchain technology and its components.
2. Explore the synergy between blockchain and artificial intelligence (AI) & machine learning (ML).
3. Apply ML techniques for blockchain data analytics and optimization.
4. Evaluate blockchain frameworks for secure, trustworthy AI applications.
5. Develop decentralized, intelligent applications for real-world use cases.

Unit 1: Fundamentals of Blockchain
Basics of Blockchain: Structure, Blocks, Chains, Hashes, Distributed Ledger Technology (DLT), Consensus Mechanisms: Proof of Work, Proof of Stake, PBFT, Smart Contracts and Decentralized Applications (DApps), Public, Private, and Consortium Blockchains

Unit 2: Introduction to AI & ML
Overview of Artificial Intelligence and Machine Learning, Types of ML: Supervised, Unsupervised, Reinforcement Learning, Common Algorithms: Decision Trees, SVM, Clustering, Neural Networks, AI Lifecycle and Data Pipeline, Tools: Scikit-learn, Tensor Flow, Keras.

Unit 3: Blockchain for AI & ML
Trust, Transparency, and Security in AI using Blockchain, Federated Learning with Blockchain Support, Verifiable Data Sharing and Provenance, Decentralized ML Model Marketplaces, Use Cases: Healthcare, Finance, Identity Management

Unit 4: AI & ML for Blockchain Optimization
Fraud Detection in Blockchain Systems using ML, Predictive Analytics on Blockchain Transaction Data, Intelligent Smart Contract Validation and Optimization, AI for Blockchain Scalability and Energy Optimization, Use Cases: Anomaly Detection, Spam Prevention

Unit 5: Tools, Frameworks, and Applications
Blockchain Platforms: Ethereum, Hyperledger, Polygonal/ML + Blockchain Integration Frameworks: Ocean Protocol, Singularity NET, Data Privacy and Security Regulations (GDPR, DPDP Act), Challenges and Limitations of AI-Blockchain Integration, Future Trends: Web3, AI Agents on Blockchain, Tokenized AI Models

Text Book(s):

1. Imran Bashir, "Mastering Blockchain: Unlocking the Power of Crypto currencies, Smart Contracts, and Decentralized Applications", Packt Publishing, 4th Edition, 2023
2. Vikram Dhillon, David Metcalf, Max Hooper, "Blockchain Enabled Applications: Understand the Blockchain Ecosystem and How to Make it Work for You", Apress, 1st Edition, 2017
3. Anurag Bhardwaj, Vinit Tanwar, "Artificial Intelligence and Blockchain for Future Cybersecurity Applications", CRC Press, 1st Edition, 2021

Reference Book:

1. Rashmi Agrawal, Meenu Gupta, Neha Gupta, "Integrating Blockchain Technology into the AI Ecosystem", IGI Global, 1st Edition, 2022
2. Kolla Bhanu Prakash, "Blockchain for AI: Decentralized Intelligence", Wiley-Scrivener, 1st Edition, 2021
3. Seung-Hyun Hong, Ajith Abraham, Aboul Ella Hassanien, "Blockchain and Deep Learning: Future Trends and Applications", Springer, 1st Edition, 2023

Professional Elective –IV

Course Code	BEPE705				
Category	Minor				
Course title	AI Driven Edge Computing				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals and architecture of edge computing.
2. Explore integration of AI with edge computing systems.
3. Design and deploy machine learning models at the edge.
4. Evaluate real-time and resource-constrained AI applications.
5. Implement intelligent edge-based solutions for smart environments.

Unit 1: Introduction to Edge Computing
Need for Edge Computing: Latency, Bandwidth, Privacy, Edge vs Cloud vs Fog Computing, Architecture of Edge Systems: Devices, Gateways, Edge Servers, Key Technologies: 5G, IoT, Embedded AI, Use Cases: Smart Cities, Smart Homes, Industry 4.0

Unit 2: Fundamentals of AI at the Edge
AI Workflows and Requirements, Types of AI Tasks Suitable for Edge: Classification, Detection, Prediction, Constraints: Computation, Energy, Storage, Optimization Techniques: Model Compression, Quantization, Pruning, Tools: TensorFlow Lite, ONNX, PyTorch Mobile

Unit 3: Edge AI Hardware and Frameworks
Hardware Platforms: Raspberry Pi, NVIDIA Jetson, Google Coral, ARM Cortex, Edge Accelerators and TPUs, Edge Deployment Frameworks: Edge Impulse, AWS Greengrass, Azure IoT Edge, Model Deployment Pipelines, Security and Reliability of Edge Devices,

Unit 4: Real-time AI and Streaming Analytics
Real-Time Data Processing at the Edge, Stream Analytics Frameworks: Apache Kafka, Apache Flink, Video Analytics using AI at Edge, Event-Driven and Time-Series Models, Performance Evaluation Metrics

Unit 5: Applications, Challenges, and Trends
Intelligent Transportation, Healthcare Monitoring, Smart Manufacturing, Privacy Preservation and Federated Learning at the Edge, Interoperability and Standardization, Challenges: Scalability, Device Management, Update Mechanisms, And Emerging Trends: TinyML, AIoT, and Edge Autonomy.

Text Book:

1. Pethuru Raj, Preetha Evangeline, Jeeva S. Chelladhurai, "The Journey of Edge Computing: From Cloud to Edge and Beyond", Wiley, 1st Edition, 2021
2. Kai Hwang, Jack Dongarra, Geoffrey C. Fox, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things", Morgan Kaufmann, 1st Edition, 2012
3. Samarjit Chakraborty, Weisong Shi, "Edge Computing: Models, Technologies and Applications", Springer, 1st Edition, 2022

Reference Book:

1. Yatish Patil, Sachin Shetty, "Artificial Intelligence for Edge Computing: Frameworks, Tools and Applications", Springer, 1st Edition, 2022
2. Alfredo Cuzzocrea, Jinjun Chen, Le Gruenwald, "Edge AI: Convergence of Edge Computing and Artificial Intelligence", CRC Press, 1st Edition, 2023
3. Meikang Qiu, "AI and Machine Learning for Edge Computing", Springer, 1st Edition, 2022

Course Code	BEPE706				
Category	Minor				
Course title	Human-AI Interaction				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the principles and design challenges of Human-AI Interaction (HAI).
2. Analyze user experience, trust, and interpretability in AI systems.
3. Apply HCI and UX principles to develop human-centered AI interfaces.
4. Evaluate interaction patterns between humans and intelligent systems.
5. Explore ethical, social, and psychological aspects of Human-AI collaboration.

Unit 1: Introduction to Human-AI Interaction
Overview of Human-AI Interaction, Differences between Human-Computer and Human-AI Interaction, Core Concepts: Intelligence, Agency, Transparency, Control, AI System Types: Recommender Systems, Conversational Agents, Decision Support Systems, Applications: Education, Healthcare, Autonomous Systems

Unit 2: Interaction Design and Usability
Human-Cantered Design (HCD) Principles, Usability Metrics: Effectiveness, Efficiency, Satisfaction, Designing AI Interfaces: Feedback, Affordances, Adaptivity, Challenges in Interactive AI: Ambiguity, Autonomy, User Expectation, Case Studies: Smart Assistants, Chatbots, Robo-Advisors

Unit 3: Explainability and Trust in Human-AI Interaction
Explainable AI (XAI) in User Interfaces, Visualizing Model Decisions and Uncertainty, Building Trust in AI Systems, Transparency and Intelligibility in AI Recommendations, Trust Calibration and Human Over-reliance

Unit 4: Cognitive and Affective Aspects
Cognitive Load and Human Perception in AI Interfaces, Emotion Recognition and Affective Computing, Adaptive Interaction: Personalization and Context-Awareness, Multimodal Interaction: Speech, Gesture, Touch, Measuring Engagement and Satisfaction

Unit 5: Ethics, Policy, and Future Trends
Ethical Considerations: Bias, Privacy, Accountability, Inclusive and Fair AI System Design, Human-AI Teaming and Decision Sharing, Emerging Interfaces: AR/VR in Human-AI Interaction, Future Directions: Empathic AI, Long-Term Human-AI Collaboration

Text Book:

1. Ehsan T. Esfahani, "Human-Centered AI: A Systems Engineering Perspective", Springer, 1st Edition, 2023
2. Catherine D'Ignazio and Lauren F. Klein, "Data Feminism", MIT Press, 1st Edition, 2020
3. Jonathan Grudin, "From Tool to Partner: The Evolution of Human-Computer Interaction", Morgan & Claypool Publishers, 1st Edition, 2017

Reference Book:

1. Ben Shneiderman, "Human-Centered AI", Oxford University Press, 1st Edition, 2022
2. Yoram Chisik, Luca Chittaro, "Advances in Human-Computer Interaction and AI", IGI Global, 1st Edition, 2021
3. Andrea Bunt, Leah Findlater, Joanna McGrenere, "Designing User Interfaces for an AI World", Springer, 1st Edition, 2023

Course Code	BEPE707				
Category	Minor				
Course title	Tiny ML				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the fundamentals of Tiny Machine Learning (TinyML) and edge AI.
2. Deploy machine learning models on low-power, memory-constrained devices.
3. Optimize ML models for inference on microcontrollers.
4. Develop real-world IoT applications using TinyML.
5. Address challenges of latency, power, and memory in embedded AI systems.

Unit 1: Introduction to TinyML
Definition and Scope of TinyML, Need for TinyML: Latency, Energy Efficiency, Privacy, and Architecture of TinyML Systems: Sensors, Microcontrollers, Models, Comparison with Cloud and Edge ML, and Applications: Wake Word Detection, Gesture Recognition, and Predictive Maintenance

Unit 2: Machine Learning Fundamentals for TinyML
Overview of Supervised Learning, Neural Networks, Training vs Inference, Lightweight Models: Logistic Regression, Decision Trees, Shallow Neural Nets, Datasets for TinyML: Speech, Sensor Data, Accelerometers, Deployment Considerations: Latency, Throughput, Accuracy

Unit 3: Hardware Platforms and Toolchains
Microcontrollers: ARM Cortex-M, Arduino Nano 33 BLE Sense, ESP32,Energy and Memory Constraints, Toolchains: TensorFlow Lite for Microcontrollers (TFLM), Edge Impulse, Model Conversion and Quantization, Real-Time OS (RTOS) for ML Inference

Unit 4: Model Optimization and Deployment
Techniques: Quantization, Pruning, Knowledge Distillation, Model Compression for Deployment, Flash vs SRAM Optimization, Case Studies: Keyword Spotting, Anomaly Detection, Image Classification, On-Device Learning and Continual Learning Challenges

Unit 5: Applications, Challenges, and Future Directions
Real-World Use Cases in Healthcare, Agriculture, Industrial Monitoring, Security and Privacy in ,TinyML Devices, Ethical AI in Tiny Devices, Future Trends: Federated TinyML, Bio-inspired Models, Self-learning Sensors, TinyML Ecosystem and Community Initiatives

Text Book:

1. Pete Warden, Daniel Situnayake, "TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers", O'Reilly Media, 1st Edition, 2019
2. Arm Education, "Fundamentals of TinyML", Arm Education Media, 1st Edition, 2021
3. Deepak Vasisht, Mohamed A. Abdallah, "TinyML: Intelligent Machine Learning on Edge Devices", Springer, 1st Edition, 2023

Reference Book:

1. Vaibhav Verdhan, "Applied Machine Learning for Smart IoT Devices: TinyML for Edge Intelligence", Apress, 1st Edition, 2022
2. Ganesh Prasad Kumble, "TinyML Cookbook: Deploying Edge ML Solutions with TensorFlow Lite", Packt Publishing, 1st Edition, 2022
3. Bharat Sikka, Pradeep Singh, "Hands-On TinyML", BPB Publications, 1st Edition, 2023

Course Code	BEPE708				
Category	Minor				
Course title	Federated Learning				
Scheme & Credits	L	T	P	Credits	Semester VII
	3	0	0	3	
Pre-requisite (if any)	None				

Course Outcomes (COs):

1. Understand the concepts and architecture of Federated Learning (FL).
2. Analyze the need for privacy-preserving distributed machine learning.
3. Design FL systems using appropriate algorithms and communication strategies.
4. Explore challenges in FL such as heterogeneity, security, and scalability.
5. Apply federated learning in healthcare, finance, and edge computing domains.

Unit 1: Introduction to Federated Learning
Definition and Evolution of Federated Learning, centralized vs. Decentralized vs. Federated Learning, Applications: Healthcare, IoT, Smart Devices, Banking, FL System Components: Clients, Server, Aggregator, Motivations: Privacy, Data Ownership, Legal Compliance

Unit 2: Federated Learning Algorithms
Federated Averaging (FedAvg), Client Selection and Participation Models, Synchronous vs Asynchronous FL, Personalization in FL, Use Cases: Google Keyboard, Federated Recommendation

Unit 3: Communication and Optimization in FL
Communication-Efficient FL: Compression, Quantization, Sparsification, Bandwidth Constraints and Edge Deployment, Adaptive Federated Optimization, Gradient Sharing and Secure Aggregation, Client-Server Communication Patterns

Unit 4: Privacy, Security, and Fairness
Differential Privacy in FL, Secure Multiparty Computation (SMPC), Holomorphic Encryption, Threat Models: Poisoning, Backdoor, Eavesdropping, Fairness and Bias Mitigation in, federated Settings

Unit 5: Challenges, Tools, and Emerging Trends
System Heterogeneity and Non-IID Data, Tools and Frameworks: TensorFlow Federated, PySyft, Flower, Scalability and Fault Tolerance, Emerging Areas: Cross-device vs Cross-silo FL, Hierarchical FL, Research Trends: Federated Meta-learning, FL + Block chain

Text Book(s):

1. Qiang Yang, Yang Liu, Tianjian Chen, Yongxin Tong, "Federated Learning", Morgan & Claypool Publishers, 1st Edition, 2019
2. Jianyi Liu, Yidong Chen, Liang Wang, "Federated Learning: Foundations and Applications", Springer, 1st Edition, 2022
3. Kai Hwang, Min Chen, "Big Data Analytics for Cloud, IoT and Cognitive Computing: Theory and Practice", Wiley, 1st Edition, 2017

Reference Book:

1. Chuanxin Lan, Shiqiang Wang, Weisong Shi, "Federated Learning Systems: Concepts, Design, and Applications", Springer, 1st Edition, 2023
2. Jakub Konečný, Brendan McMahan, Daniel Ramage, "Advances in Federated Learning", Springer, 1st Edition, 2021
3. Liang Wang, Yidong Chen, "Security and Privacy in Federated Learning", Springer, 1st Edition, 2022

Semester VIII

Detailed Fourth Year Curriculum Contents

Course Code	BAML821				
Category	Dissertation				
Course title	Major Project				
Scheme & Credits	L	T	P	Credits	Semester VIII
	0	0	44	22	
Pre-requisite (if any)	None				

To provide students with the opportunity to undertake a comprehensive, research-oriented or application-based project in the domain of Artificial Intelligence and Machine Learning. The project should demonstrate the ability to solve real-world problems through advanced model development, data-driven analysis, or AI/ML system implementation.

Students will be evaluated based on technical depth, innovation, implementation, documentation, and final viva or presentation.

Students in the final semester may also undertake their Major Project or Dissertation at a reputed external academic institution or industry. However, prior permission from the University must be obtained at the end of the 7th semester.

Note: Detailed guidelines, timelines, and report formats are provided in a separate document.