WEST BENGAL COUNCIL OF HIGHER SECONDARY EDUCATION
SYLLABUS FOR CLASS XI AND XII
SUBJECT : ARTIFICIAL INTELLIGENCE (ARTI)

Course Objectives :

The objectives of this course are:

- To impart knowledge about basic computer fundamentals and programming environments required for implementing Artificial Intelligence (AI) systems.
- To enable the students to understand the history of AI and the basic principles of modern AI.
- To enable students to learn the informed and uninformed search methods, and a simple evolutionary algorithm for solving problems.
- To enable students to understand the fundamentals of knowledge representation, building of simple knowledge-based systems, and to apply knowledge representation and reasoning
- To enable the students to understand important machine learning(ML) algorithms used for improving various components of an AI agent
- To enable the students to understand the uses of AI and ML in various applications.
- To enable the student to understand ethics in AI
- To gain practical experience in developing various AI and ML models

Course outcomes:

Upon successful completion of this course, the student shall be able to:

- Demonstrate an understanding of the history of AI and its foundations.
- Apply basic principles of AI in problem-solving that require perception, knowledge representation , inference, and learning.
- Demonstrate awareness and a fundamental understanding of various applications of AI and Machine Learning techniques in real-world problem solving.
- Demonstrate proficiency in developing various real-world AI and ML applications using the latest programming languages and software tools.
- Demonstrate an ability to share in discussions of AI and ML, its current scope and limitations, and its impact on society.

CLASS - XI

SEMESTER – I

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

FULL MARKS: 35 **CONTACT HOURS: 60 Hours**

COURSE CODE: THEORY

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
Unit -1 Computer Fundamental (15)	1a	History of computer, Basic Computer hardware, input and output devices, Basic computer architecture, input output devices, memory and CPU, networking of machines (overview of LAN, MAN, WAN, Internet, Wifi etc), types of computer (workstation, desktop, Smartphone, embedded system, etc.), Overview of Software (system software and application software with examples (mention names only), Definition of Operating System and functions (mention names of some popular operating systems like Windows, Linux, Android, etc).	8	5
	1b	Bit, Byte and Word, Number System (Base, Binary, Decimal, Octal, Hexadecimal), Conversion of number systems, Boolean logic (Boolean Gates), Boolean operators (OR, AND and NOT), ASCII code, Concept of Algorithm and Flowchart.	6	5
	1c	Basics of Computer Programming (three levels: high level language, assembly language, machine language, definition and block diagrams), Overview of Compiler and Interpreter (definition and mention name of major compiled (e.g., C, C++) and interpreted languages (e.g., Python), Overview of procedural and object oriented programming (key features and just the basic differences, mention names of some popular procedural (e.g., BASIC, FORTRAN, C) and object oriented programming languages (e.g., C++, Java, Python).	10	5

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
Unit -2 Introduction to Python Programm-ing (15)	2a	Basics of Python programming (with a simple 'hello world' program, process of writing a program, running it, and print statement), Concept of class and object, Data-types (integer, float, string), Notion of a variable, Operators (assignment, logical, arithmetic etc.), accepting input from console, conditional statements (If else and Nested If else), Collections (List, Tuple, Sets and Dictionary), Loops (For Loop, While Loop & Nested Loops), Iterator, String and fundamental string operations (compare, concatenation, sub-string etc.), Function, Recursion.	12	5
	2b	Overview of linear and non-linear data structure (definition, schematic view and difference), array (1D, 2D and its relation with matrix, basic operations: access elements using index, insert, delete, search), stack (concept of LIFO, basic operations: Push, Pop, peek, size), queue (concept of FIFO, basic operations: Enqueue, Dequeue, peek, size), use of List methods in python for basic operations on array, stack and queue, overview of NumPy library and basic array operations (arrange(), shape(), ndim(), dtype() etc.), binary tree (definition and schematic view only) .	12	6
	2c	Linear search and binary search algorithm, sorting algorithm (bubble sort only)	4	4
Unit -3 Introduction to Linear Algebra (5)	3	Basic matrix operations like matrix addition, subtraction, multiplication, transpose of matrix, identity matrix. A brief introduction to vectors, unit vector, normal vector, Euclidean space Probability distribution, frequency, mean, median and mode, variance and standard deviation, Gaussian distribution, Distance function, Euclidean norm, distance between two points in 2D and 3D and extension of idea to *n* dimensions	8	5

NB : Additional 10 hours for Remedial and/or Tutorial classes

CLASS - XI

SEMESTER – II

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

FULL MARKS: 35 **CONTACT HOURS: 60 HOURS**

COURSE CODE: THEORY

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
Unit -4 Foundation of AI & Search as Optimization (18)	4a	History of AI: Alan Turing and cracking enigma, mark 1 machines, 1956-the birth of the term AI, AI winter of 70's, expert systems of 1980s, skipped journey of present day AI. Distinction between terms AI, Pattern recognition and Machine Learning **Note: should be taught as a story more than flow of information World war 2, Enigma and Alan Turing, the birth of modern computers.**	6	3
	4b	Search as optimization: how to search for the best answer to a question? playing tic-tac-toe ● State Space Search, different states as different solutions of a problem ● Mathematical equation for optimizing a result, example tic-tac-toe, the states of the board and equation to calculate score of the board with respect to a player ● Expanding possible states from a state and choosing the best state Uninformed search a) Breadth first search b) Depth first search Informed search a) Heuristic search strategy with tic tac toe example b) Greedy best-first search c) A* search - basic idea only**(without proof)** d) Hill climbing **(only basic idea with a small example)** e) Simulated Annealing **(No algorithm, Only basic idea)**	16	10
	4c	Evolution and Darwin's theory, inspiration of evolutionary algorithms, crossover and mutation, Russian roulette for random selection, optimization using genetic algorithm, one use of GA (to be chosen) practical: mention libraries and problem. ● Natural evolution theory, survival of the fittest ● Expressing a solution vector as gene, example of binary strings ● Crossover and mutation, its equivalent over binary strings ● Random selection of genes from pool and random mutation ● Fitness function ● Practical example by finding the root of a univariate equation.	10	5

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
5 Knowledge representation and reasoning (10)	5	Logic in computer science, propositional logic, logic as expressions, truth table, conjunction, disjunction, syllogism, tautology, De Morgan's theorem. Use of logic to derive conclusions with practical examples [NO LAB COMPONENT] ● Statements as logical propositions ● Atomic and compound propositions ● Negation, conjunction and disjunction as NOT, AND and OR ● Implication and Biconditional statements ● Truth table as a way of proving propositions ● Commutativity and Associativity and Distributive rules ● De Morgan's theorem ● Practical examples to infer meanings from statements ● Simple concept of Unification (without details of MGU) ● Simple concept of clause **(With Simple example)** ● Basic concept of Inference **(With Simple example)** ● Example of Answer Extraction system ● A brief introduction to fuzzy logic **(Only basic idea)**	16	10
6 Uncertainty Management (5)	6	Handling Uncertain Knowledge Uncertainty and Rational decision Probabilistic Reasoning Bayes Rule Conditional probability Probabilistic inference using Bayes rule a. General method(Simple cases) b. Combining evidence	8	5
7 Preliminary Concept of Chatbots (2)	7	What is Chatbot? • Examples of different Chatbots • The flowchart describing basic working principle of Chatbots.	4	2

NB : Additional 10 hours for Remedial and/or Tutorial classes

CLASS: XI

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

COURSE CODE: PRACTICAL

FULL MARKS: 30 **CONTACT HOURS: 60 HOURS**

Sub Topic

SL NO	TOPICS	CONTACT HOURS	MARKS
1. Computer Fundamentals [No marks]			
1a	• Visit to Computer Lab and familiarization with computers and peripherals and different networking devices (e.g., modem, switch, router). • Opening of the CPU box/cabinet and identification of different parts (e.g., Motherboard, CPU/Processor, RAM, Hard Disk, power supply).	6	0
2. Introduction to Python Programming [15 Marks]			
2a	• Introduction to installation and running of python codes with hello world and simple accessing user inputs from console examples. • Menu driven arithmetic calculator • Simple logical and mathematical programs (e.g., printing patterns, Conversion of binary to decimal and vice versa, Computing GCD of two numbers, Finding prime numbers, Generating Fibonacci sequence, Computing factorial –iterative and recursive etc.) • Finding max, min, avg, sum, length of a list • Use of basic string methods like upper(), lower(), count(), find(), join(), replace(), split() etc.	12	3
2b	• Use of Python List methods for Stack and Queue implementation, for examples, append() and pop() • Use of NumPy array methods: arrange(), shape(), ndim(), size(), add(), subtract(), multiply(), divide(), mat() etc. • Use of NumPy matrix multiplication methods: dot(), matmul(), multiply() etc.	6	7

SL NO	TOPICS	CONTACT HOURS	MARKS
2c	• Linear search and binary search in an array • Bubble sort in an array	4	5
3. Foundation for AI [3 Marks]			
3a	• Generation of random numbers in python following a Gaussian distribution and filling up random arrays • Introduction to matplotlib to plot arrays as histograms • Computation of mean, median and mode • Plotting Gaussian distribution with a given mean and standard deviation	8	3
4. Search as Optimization (basic principles and example based understanding) [12 Marks]			
4a	• Implementing 8-puzzle problem using DFS and BFS • Use of class to denote state of a problem, example board state of tic tac toe • Expansion of possible states from a given state with all possible moves • Score function of each state and selection of highest score or least cost at each level, i.e. making game tree	20	7
4b	• Use of a class with an array and fitness score to define a solution of a problem, example root finding of a linear equation with the solution stored in binary. Basic genetic algorithm • Binary crossover and mutation, selection using CDF of random distribution, i.e Russian Roulette	4	5

NB : Additional 10 hours for Remedial and/or Tutorial classes

CLASS - XII

SEMESTER – III

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

FULL MARKS: 35 **CONTACT HOURS: 60 Hours**

COURSE CODE: THEORY

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
1 Foundation of Statistics for Machine Learning (5)	1	Distance between distributions - Euclidean norm, Pearson correlation coefficient, basic concepts of (not in details) chi square distance, Bayes theorem and Bayesian probability ● Real *n* dimensional space (R^n) and Vector Algebra ,dot product of two vectors, vector projections. ● Product moment correlation coefficient (Pearson's coefficient) its use in determining relation between two sets of data ● Chi square and , use in finding distance between two distributions ● Conditional probability and Bayes theorem , conditional independence	10	5
2 Introduction to Machine Learning (15)	2a	• What is machine learning? • Difference between traditional programming and Machine Learning • Relation of Machine Learning with AI • Applications of machine learning • Why should machines have to learn? Why not design machines to perform as desired in the first place? • Types of Machine Learning (Supervised, Unsupervised, Semi-supervised and reinforcement learning) • Linear Regression with one variable • Hypothesis representation, hypothesis space • Learning requires bias • Concept of training examples • Concept of Loss function , • Training methods: Iterative trial-and-error process that machine learning algorithms may use to train a model, Disadvantages of iterative training method, Mean Squared Error(MSE), Gradient descent algorithm. Effect of learning rate on reducing loss, Importance of feature scaling (min-max normalization).	16	10
	2b	What is a feature or attribute? Some examples Types of features(continuous, categorical) Representation of training examples with multiple features Linear Regression with multiple attributes (**Only formula for finding weight vector without Derivation)** Feature cross and Polynomial Regression	8	5

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
3. Supervised Learning (15)	3a	• Difference between regression and classification. • Examples of some real world classification problems, • Linear classification and threshold classifier, Concept of misclassification error, accuracy. • Concept of input space and linear separator • Drawback of threshold classifier • Logistic regression model (without derivation) • Use of logistic function in defining hypothesis function for logistic regression model. • Probabilistic interpretation of output of the logistic regression model • Use of logistic regression model in binary classification task. • Multi-class classification using One *vs.* all strategy. • Instance based learning, K-nearest neighbor classifier, curse of dimensionality	18	10
	3b	Measuring Classifier performance: confusion matrix, true positive, true negative, false positive, false negative, error, accuracy, precision, recall, F-measure, sensitivity and specificity, K-fold cross validation	8	5

NB : Additional 10 hours for Remedial and/or Tutorial classes

CLASS - XII

SEMESTER – IV

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

FULL MARKS: 35 **CONTACT HOURS: 60 HOURS**

COURSE CODE: THEORY

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
4 Unsupervised Learning (15)	4a	What is supervised learning Name some of the supervised learning algorithm Probabilistic classifier: Basics of Bayesian Learning, Conditional independence, Naive Bayes classifier. Applications of Naive Bayes Classifier to sentiment classification task, add-one smoothing. Decision tree Learning: Concept of entropy for measuring purity (impurity) of a collection of training examples. and information gain as a measure of the effectiveness of an attribute in classifying the training data **(just basics and equation)** . Inducing decision tree from the training data using the ID3 algorithm , an illustrative example showing how the ID3 algorithm works. Concept of overfitting, reduced error pruning, Discretizing continuous-valued Attributes using information gain-based method **(binary split only)**	20	10
	4b	• What is unsupervised learning? • Difference between supervised and unsupervised learning. • What is clustering? • Why is clustering and unsupervised learning technique? • Some examples of real world application of clustering, • Difference between clustering and classification. • K-means clustering algorithm. Simple use cases	12	5

UNIT NO.	SUB UNIT	TOPICS	CONTACT HOURS	MARKS
5 Artificial Neural Network (17)	5a	● Biological motivation for Artificial Neural Networks(ANN) ● A simple mathematical model of a neuron (McCulloch and Pitts(1943)) ● Concept of activation function: threshold function and Sigmoid function, ● Perceptron as a linear classifier, perceptron training rule ● Representations of AND and OR functions of two inputs using threshold perceptron. ● Equation of a linear separator in the input space, Representational power of perceptrons ● Training unthresholded perceptron using Delta rule(with derivation) , Need for hidden layers , XOR example, ● Why do we need non-linearity? Network structures: feed forward networks and recurrent networks **(basic concept only)** ● Training multiplayer feed-forward neural networks using Back propagation algorithm **(Concepts only and no derivation).** ● Generalization, overfitting, and stopping criterion, overcoming the overfitting problem using a set of validation data ● An Illustrative example of an ANN architecture for handwritten digit recognition **(Only input representation, output representation and a block diagram of the network)** ● Need for automatic feature learning, difference between the conventional feed-forward neural networks and CNN, role of convolution layer in CNN, An example of 2D convolution, function of pooling layer ● A block diagram illustrating CNN applied to handwritten digit recognition task	26	17
6 Ethics in AI (3)	6a	Brief discussion on important ethical issues in AI	2	3

NB : Additional 10 hours for Remedial and/or Tutorial classes

CLASS: XII

SUBJECT: ARTIFICIAL INTELLIGENCE (ARTI)

COURSE CODE: PRACTICAL

FULL MARKS: 30 **CONTACT HOURS: 60 HOURS**

SL NO	TOPICS	CONTACT HOURS	MARKS
1. Foundation of Statistics for Machine Learning [2 Marks]			
1a	● Calculating Euclidean distance between two vectors using a python program without using any library. ● Consider a table of data about *n* persons with two attributes-age and income and find Pearson correlation coefficient using a python program. Do not use any ready -to-use library function that directly accepts the data table and produces the output.	8	2
2. Introduction to Machine Learning [6 Marks]			
2a	● Introduction to python libraries like scipy and statsmodel to various basic codes ● Revisit matrix operations using scipy (basic matrix operations of addition, subtraction, multiplication, transpose) ● Using Scipy for advanced matrix operations - inverse	12	3
2b	• Generation of random (x, y) pairs where y = f(x) + d (d varies from -r to +r , a random value), f being a linear function • Linear regression or line fitting of the data • Optimizing the function using gradient descent • Plotting the steps using matplotlib	6	3

SL NO	TOPICS	CONTACT HOURS	MARKS
3. Supervised Learning [13 Marks]			
3a	● Building linear regression-based threshold classifier and testing the model on Diabetes Data set downloadable from UCI Machine Learning Repository ● Building Logistic regression model for binary classification of Diabetes Data. Vary learning rate and verify the impact of learning rate on classification performance. ● Introduction to the IRIS dataset, building a logistic regression for multi-class classification and testing the model on the IRIS dataset downloadable from UCI Machine Learning Repository ● Building K-nearest neighbor classifier and testing on the IRIS dataset downloadable from UCI Machine Learning Repository (Use Scikit-learn open source data analysis library for implementing the models)	16	7
3b	• Building a naive Bayes classifier for sentiment analysis (Use Scikit-learn open source data analysis library)	4	3
3c	● Loading csv file based datasets using file read operation in python ● Introduction to pandas library and loading csv and json files ● Using Scikit-learn library to develop decision tree classifier in python.	4	3
4. Unsupervised Learning [3 Marks]			
4a	Using Scikit-learn library to use the K-means algorithm for clustering IRIS data and its visualization	4	3
5. Artificial Neural Network [6 marks]			
5a	● Using MLP from Scikit learn library, develop a handwritten digit recognition model using MLP and MNIST dataset ● Using CNN from keras library, develop a handwritten digit recognition model using CNN and MNIST dataset ● Compare the performance of the MLP based model and the CNN based model for the handwritten digit recognition task	6	6