Vidya Pratishthan's Kamalnayan Bajaj Institute of Engineering and Technology, Baramati

Department of Artificial Intelligence and Data Science

T.Y. B. Tech Syllabus 2025-26 (As per NEP 2020)

Syllabus: Honor w. e. f. AY: 2025- 2026
SEMESTER-V

Honor in Artificial Intelligence and Data Science

SEM	Course Code	Courses Name	Teaching Scheme			Examination Scheme and Marks							Credits			
			TH	PR	TUT	Activity	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
V	AI23381	Intelligent Optimization Algorithms	3	2	-	10	30	60			30	130	3	1		4

Dept. Autonomy Coordinator
Mrs. R. S. Naik

Dept. Academic Coordinator
Mr. P. N. Shendage

HOD, AI&DS
Dr. C. S. Kulkarni

Dean Autonomy
Dr. C. B. Nayak

Dean Academics
Dr. S. M. Bhosle

Principal
Dr. S. B. Lande

Principal
Vidya Pratishthan's
Kamalnayan Bajaj Institute of
Engineering & Technology, Baramati
Vidyanagari, Baramati-413133

BUCKET OF HONOR SUBJECT

HONOR SUBJECT **(only for students having CGPA >= 7.5)**
AI23381: Intelligent Optimization Algorithms

Vidya Pratishthan's **Kamalnayan Bajaj Institute of Engineering and Technology, Baramati** **(Autonomous Institute)**		
AI23381- Intelligent Optimization Algorithms		
Teaching Scheme: **Theory: 3 Hours/Week** **Practical: 2 Hour/Week**	**Credits** **04**	**Examination Scheme:** **Activity Marks:10 Marks** **In Sem: 30 Marks** **End Sem: 60 Marks** **Oral: 30 Marks**
Prerequisites: Discrete Mathematics (AI23202), Data Structures (AI23201)		

Course Objectives:

- To understand the need of optimization Algorithms
- To apply the optimization techniques while solving the problems
- To understand the constraints applied and optimization of the algorithm
- To optimize searching strategies
- To understand and use Self Optimizing algorithms

After completion of the course, learners should be able to

CO1: Identify Optimization Concepts to incorporate in problem solving in effective way

CO2: To formulate given optimization problem mathematically precisely

CO3: To create model using Optimization Techniques, like linear programming, integer programming and dynamic programming

CO4: To select an optimization strategy to tackle complex optimization problems and evaluate the optimization algorithms

CO5: To distinguish strategies of Optimization Algorithms selected

CO6: To construct an Optimization strategy to solve different problems

Course Contents

Unit-I Introduction (7)

Introduction, Fundamentals of Optimization, general structure of the optimization algorithms, types of optimization problems, examples of optimization, formulation of optimization problem, classification of optimization algorithms, traveling salesman and knapsack problem

Unit-II Classical Optimization (7)

Introduction, Mathematical model of optimization, Optimality conditions, Solution techniquesPenalty function, Linear programming (LP)-Formulation of LP Problem Optimality conditions, Integer Linear Programming, LP duality-Farkas Lemma, Quadratic Programming (QP)-Convex QP problems, Convex Programming, general constraint optimization problem

Unit-III Constraint Optimization (7)

Introduction Linear Programming-Simplex Method, Revised Simplex Method, Karmarkar's Method, Duality Theorem and Transportation Problem, Non-linear Programming-Quadratic and Geometric Programming, Karush–Kuhn–Tucker (KKT) conditions test as necessary condition. Dynamic Programming- Continuous vs Discrete dynamic programming, multistage graph problem, traveling salesman and knapsack problem

Unit-IV Search Optimization (7)

Introduction, Genetic Algorithms-Initialize population, Fitness Evaluation, Reproduction, Crossover andMutation, Multimodel test function, Solving linear equations with genetic algorithm, Simulated Annealing(SA)-Annealing and Boltzmann Distribution, Parameters, SA Algorithm, Unconstrained Optimization, Basic Convergence Properties, SA Behavior in Practice and Stochastic Tunneling, Particle Swarm Optimization(PSO)-Introduction, Swarm Behavior, PSO Algorithm, Variants of PSO Algorithm

Unit-V Differential Evolution and Swarm Optimization (7)

Introduction, Differential Evolution-Introduction, Differential Evolution, Variants, Choice of Parameters Convergence Analysis and Implementation. Swarm Optimization-Swarm Intelligence,

PSO Algorithm, Accelerated PSO, Convergence Analysis-PSO, Binary PSO, Multiobjective Optimization- Pareto Optimality, Constraint Methods, Weight Methods, Preference Elicitation, Ant colony optimization(ACO)
Unit-VI Self Tuning Algorithms (7) Introduction, Algorithm Analysis and Parameter Tuning, Framework for Self-Tuning Algorithms, A Self-Tuning Firefly Algorithm- Firefly Behavior, Standard Firefly Algorithm, Variations of Light Intensity and Attractiveness, Controlling Randomization Variants of the Firefly Algorithm, Firefly Algorithms in Applications, Bat Algorithm- Echolocation of Bats, Bat Algorithms, Binary Bat Algorithms, Convergence Analysis, Applications
Text Books: 1. Andreas Antoniou, Wu-Sheng Lu, "Practical optimization algorithms and engineering applications", Springer, 2007 2. Vasuki A., "Nature Inspired Optimization Algorithms", CRC Press, 2020 3. Mykel J. Kochenderfer, Tim A. Wheeler, "Algorithms for Optimization", MIT Press, 2019
Reference Books: 1. Rajesh Kumar Arora, "Optimization Algorithms and Applications", Chapman & Hall, CRC, 2015 2. A Schrijver, "Theory of Linear and Integer Programming" (Wiley Series in Discrete Mathematics & Optimization) 3. V. Chvatal, "Linear Programming" W. H. Freeman **ISBN-13 :** 978-0716715870
MOOC Courses: **1.https://www.coursera.org/learn/optimization-for-decision-making** **2. https://www.coursera.org/learn/solving-algorithms-discrete-optimization**

Warehouse	Shop 1	Shop 2	Shop 3
Warehouse 1	3000/-	2000/-	5000/-
Warehouse 2	2000/-	7000/-	3000/-
Warehouse 3	2200/-	2400/-	1000/-

List of Assignments
1. A mechanical industry has three warehouses in the Solapur area and needs to deliver camshafts to its three shops in and around for tomorrow. The three shops demand 10, 20, and 40 units respectively. The current stock level of shafts in the three warehouses are 80, 62, and 32 respectively. Delivery costs from each warehouse to each store are different due to different distances. Find the least expensive way to deliver the chairs to the stores. The delivery cost Matrix is represented below. Use Linear Programming to write a program in python.
2. Write a python program to maximize the function with constraints find out the values of such a that it maximizes the given objective function using Quadratic Programming
3. Write a python program to minimize the flow from source S to the destination D in a multi-stage graph with a property , Here and are the partitions of the graph G and no connecting edge in the same partition. Find out a path from S to the D with minimum cost.
4. A linear equation of the form is to be solved with the help of Genetic Algorithms applying

Initialize population, Fitness Evaluation, Reproduction, Crossover and Mutation. Find out the approximate values of the coefficients with python programming

5. A delivery vehicle delivers the items to the different cities, it starts from his own city and visits all other cities once except his city of residence. You have to suggest a tour of shortest distance using Simulated Annealing

6. There is a dataset D over , supplied to the machine learning algorithm for classification purposes. We are cautious about the selection of the attributes for training and testing the model. Use Particle Swarm Optimization for feature section and show that the performance of a classification algorithm is improved over the use of PSO.

7. A Binary Particle Swarm Optimization algorithm to be applied on a dataset D for selection of the features to be used for training a binary class classifier. Mine the performance of the classifier when Binary PSO is applied.

8. A CNN based classifier uses a set of images for training and efficient testing of the model, it has the property of self tuning its parameters such that the classification accuracy reaches to the maximum possible. Use tensorflow, keras or Pytorch to write the program

9. There are different jobs to be executed on a machine, each of the job comes with a triplet {job, enter_time, exit_time}, Prepare a schedule of the jobs using `firefly algorithm to maximize the profit

10. A machine learning task requires a dataset D, has features, not necessarily all the features to be used during training and testing of the algorithm/model. Select an optimization technique like Firefly algorithm to choose the important features to be used during training of an algorithm. Write a python program with suitable libraries to carry out mentioned task

11. Mini Project:- Design and develop a mini project for classification of images into different categories using CNN along with Particle Swarm Optimization/Firefly/Binary PSO. The group of students developing this application need to use different datasets. Priority must be given for self data creation, publishing and using it in this project.

Syllabus Honor w. e. f. AY: 2025- 2026
SEMESTER-VI

Honor in Artificial Intelligence and Data Science

SEM	Course Code	Courses Name	Teaching Scheme			Examination Scheme and Marks							Credits			
			TH	PR	TUT	Activity	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
VI	AI23391	Quantum Artificial Intelligence	3	2	-	10	30	60			30	130	3	1		4

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VPKBIET BARAMATI
Affiliated to S.P.P.U. Pune
Id No./PU/PN/Engg./152/2008
PUNE (MS.)

BUCKET OF HONOR SUBJECT

HONOR SUBJECT (only for students having CGPA >= 7.5)
AI23391-: Quantum Artificial Intelligence

Vidya Pratishthan's
Kamalnayan Bajaj Institute of Engineering and Technology, Baramati
(Autonomous Institute)

AI23391- Quantum Artificial Intelligence

Teaching Scheme:	Credits	Examination Scheme:
Theory: 3 Hours/Week **Practical: 2 Hour/Week**	**04**	**Activity Marks:10 Marks** **In Sem: 30 Marks** **End Sem: 60 Marks** **Oral: 30 Marks**

Prerequisites: Introduction to Computational Intelligence, Stat and Linear Algebra, Physics(Quantum Mechanics Unit)

Course Objectives:

- To get acquainted with the principles of quantum computing and the usage of Linear algebra in Quantum Computing
- To understand the Architecture of Quantum computing and solve examples of Quantum Fourier Transforms
- To understand the concepts of basic and advanced Quantum Algorithms and apply them to various problems.
- To study quantum machine learning and apply these to develop hybrid solutions
- To study the Quantum Theory with Fault-Tolerant Quantum techniques
- To understand Problem-Solving using various peculiar search strategies for AI

Course Outcomes (COs): The students will be able to:
CO1: Understand quantum requirements and formulate design solutions using quantum circuits.
CO2: Illustrate applicable solutions in one or more application domains using a quantum architecture that integrates ethical, social, and legal concerns
CO3: Apply the Advanced Quantum Algorithms on real time problem
CO4: Analyze the quantum machine learning algorithms and their relevant application
CO5: Analyze quantum information processing & its relevant algorithms
CO6: Evaluate suitable algorithms for AI problems

Course Contents

Unit I: Introduction to Quantum Computation (7 Hours)
Overview of Quantum Computation: Single qubit gates, Multiple qubit gates, Measurements in bases Vs computational basis, Quantum circuits, Qubit copying circuit, Example: Bell states & quantum teleportation. Basics of Linear Algebra: Hilbert Spaces, Products and Tensor Products, Matrices, Graphs, and Sums Over Paths, Example.

Unit II: Knowledge Representation and Reasoning **(7 Hours)**
The Framework of Quantum Mechanics: The State of a Quantum System, Time-Evolution of a Closed System, Composite Systems, Mixed States and General Quantum Operations, Universal Sets of Quantum Gates, Quantum measurement and quantum entanglement The quantum Fourier transform and its Applications- The quantum Fourier transform, Phase estimation, order-finding and factoring, General applications of the quantum Fourier transform- Period-finding, Discrete logarithms, The hidden subgroup problem

Unit III: Quantum Algorithms (7 Hours) Probabilistic Versus Quantum Algorithms, Phase Kick-Back, The Deutsch Algorithm, The Deutsch–Jozsa Algorithm, Simon's Algorithm, Shor's Algorithm, Factoring Integers, Grover's Algorithm
Unit IV: Quantum Machine Learning (7 Hours) Quantum Enhanced Machine Learning: Quantum Algorithms for Linear Algebra, Regression, Clustering, Nearest Neighbour Search, Classification. Quantum Boosting, Quantum Support Vector Machines, Quantum Neural Networks, Variational Quantum Algorithms.
Unit V:Quantum Information Processing(7 Hours) Classical Error Correction: The Error Model Encoding, Error Recovery, The Classical Three-Bit Code, Fault Tolerance. Quantum Information: Quantum Teleportation, Quantum Dense Coding, Quantum Key Distribution, Noise and error models in quantum systems, Quantum cryptography and secure communication.
Unit VI: Quantum Problem Solving & AI applications (7 Hours) Quantum Problem Solving: Heuristic Search, Quantum Tree Search, Quantum Production System, Tarrataca's Quantum Production System Quantum AI Application: Introduction to Pennylane: a cross-platform Python library, Quantum Neural Computation, Quantum Walk – Random insect, Walk on graph, Case studies on Quantum-centric supercomputing: The next wave of computing, Quantum computing for data sciences
Text Books: 1. Nielsen, M. & Chuang I., "Quantum Computation and Quantum Information", 2002 2. Lipton and Reagan, "Quantum Algorithms via Linear Algebra: A Primer" 3. Kaye, LaFlamme and Mosca's, "Introduction to Quantum Computing" 4. Biamonte, J. et al., "Quantum Machine Learning", Nature, 2017 5. Andreas Wichert, "Principles Of Quantum Artificial Intelligence"
Reference Books: 1. Rieffel, E. G. & Polak W. H., "Quantum computing: A gentle introduction", MIT Press, 2011 2. Farhi, E., Goldstone, J. & Gutmann, S., "A quantum approximate optimization algorithm", arXiv preprint arXiv:1411.4028, 2014 3. Kuttler, "Elementary Linear Algebra", 2012 4. Kepner and Gilbert, "Graph Algorithms in the Language of Linear Algebra", 2011 5. Russell, S. & Norvig, P., "Artificial Intelligence: A modern approach", 4 th edition, Pearson Education, 2021
E-Resources: **1.http://mmrc.amss.cas.cn/tlb/201702/W020170224608149940643.pdf** **2.https://arxiv.org/pdf/1611.09347.pdf** **3.http://mmrc.amss.cas.cn/tlb/201702/W020170224608150244118.pdf** **4.https://www.researchgate.net/publication/282378154_FPGA -based_quantum_circuit_emulation** **5.Microsoft Quantum Development Kit: https://www.microsoft.com/enus/quantum/development-kit Forest**

6. Learn quantum programming: https://pennylane.ai/qml/
7. Quantum machine learning: https://qiskit.org/learn/course/machine-learning-course/
8. Center for Excellence in Quantum Technology: https://research.ibm.com/blog/next-wave-quantumcentric-supercomputing

List of Assignments

1. In quantum computing, Bell states are a fundamental example of quantum entanglement. Quantum teleportation allows transferring quantum states between qubits using entanglement and classical communication.

Tasks:

- Implement a **quantum circuit** to generate the four Bell states using Hadamard and CNOT gates.
- Simulate **quantum teleportation** of an arbitrary qubit state using an entangled Bell pair.
- Measure the output and verify that the original state is reconstructed at the receiver.

Expected Outcome:

- Correct generation of Bell states.
- Successful transmission of quantum states using teleportation.
- Visualization of measurement results.

2. Quantum circuits use multiple qubit operations such as controlled gates (CNOT, Toffoli) to create entanglement. This assignment explores the effect of different gates on quantum states.

Tasks:

- Construct a quantum circuit using **Hadamard, Pauli-X, and CNOT gates**.
- Implement a **Toffoli (CCNOT) gate** and demonstrate its effect on a 3-qubit system.
- Simulate the circuit using Qiskit and analyze the measurement outcomes.

Expected Outcome:

- Correct implementation of multi-qubit gate operations.
- Understanding of quantum entanglement and state evolution.

3. The Quantum Fourier Transform (QFT) is a fundamental operation in quantum algorithms such as phase estimation. This assignment requires implementing QFT and inverse QFT using Qiskit.

Tasks:

- Implement **QFT** for a 2-qubit and 3-qubit system.
- Verify the correctness of QFT by applying its inverse and checking if the input state is

recovered.

- Analyze the measurement results to understand the frequency domain representation.

Expected Outcome:

- Correct implementation of QFT and inverse QFT.
- Verification of transformation properties through simulation.

4. Quantum measurement collapses superposition states. This assignment explores quantum measurement and entanglement using Qiskit.

Tasks:

- Construct a **quantum circuit** that demonstrates **superposition and measurement** using Hadamard and measurement gates.
- Implement **quantum entanglement** between two qubits and demonstrate Bell inequality violation.
- Simulate the circuit and visualize measurement results.

Expected Outcome:

- Understanding of quantum measurement and state collapse.
- Demonstration of entanglement using Qiskit.

5. The **Deutsch-Jozsa algorithm** determines if a function is **constant** or **balanced** using quantum parallelism. This assignment implements the algorithm for a 2-qubit system.

Tasks

- Implement the Deutsch-Jozsa algorithm for a 2-qubit system in Qiskit.
- Define **constant and balanced functions** and verify their classification.
- Measure the output and analyze the probability distribution.

Expected Outcome:

- Efficient determination of function type in a single quantum evaluation.

6. Shor's algorithm is a **quantum factorization algorithm** that efficiently finds the prime factors of a composite number. This assignment involves simulating Shor's algorithm using Qiskit.

Tasks

- Implement a **quantum circuit** for Shor's algorithm for factoring **15** (3 × 5).

- Simulate the algorithm and verify its ability to find factors.
- Analyze the effect of quantum phase estimation in the process.

Expected Outcome

- Understanding of **period finding** in integer factorization.
- Verification of quantum speedup for factorization.

7. Support Vector Machines (SVMs) are widely used for classification. Quantum Support Vector Machines (QSVMs) use quantum kernels to classify data more efficiently.

Tasks

- Implement **QSVM** using Qiskit's quantum machine learning module.
- Train QSVM on a **binary classification dataset** (e.g., distinguishing handwritten digits 0 and 1).
- Compare the performance of QSVM with a classical SVM.

Expected Outcome

- Successful classification using QSVM.
- Performance comparison with classical SVM.

8. Variational Quantum Classifiers (VQCs) are **quantum neural networks** that use parameterized quantum circuits for machine learning.

Tasks

- Implement a **VQC** using Qiskit's `qml` module.
- Train the model on a simple dataset and classify test samples.
- Analyze the impact of quantum circuit depth on classification accuracy.

Expected Outcome

- Quantum-enhanced classification using **variational circuits.**

9. Quantum cryptography enables secure communication using quantum key distribution (QKD). The **BB84 protocol** ensures secure key exchange between Alice and Bob.

Tasks

- Implement the **BB84 quantum cryptography protocol** using Qiskit.
- Simulate an eavesdropper attack and measure its effect on security.
- Analyze the probability of successful key distribution.

Expected Outcome

- Secure quantum key exchange using BB84.

- Detection of eavesdropping attempts.

10. Quantum walks provide an alternative to classical random walks and are useful in **AI search algorithms**.

Tasks

- Implement a **Quantum Walk** on a **graph** using Qiskit.
- Simulate a **random walk of an insect on a 1D line** and measure probabilities at different positions.
- Compare quantum and classical random walk behavior.

Expected Outcome

- Understanding of **quantum walk dynamics**.
- Speedup in search algorithms using quantum walks.