First Task.

Question 1:

1. **What is the rank of a matrix? Why is it important in machine learning?**

   It's the maximum number of independent columns or rows. It's very important in machine learning to understand the data dimensionality such as dimensionality reduction (data with a lot of features) and ensure features are informative.

2. **Explain eigenvalues and eigenvectors. How are they used in PCA?**

   Eigenvalues are scalars that represent the magnitude of variance in data, while eigenvectors correspond to the direction of this variance. These concepts are essential in PCA which is Principal Component Analysis, a technique used for reducing the dimensionality of datasets. PCA projects data onto a smaller set of directions that maximize variance which helps in simplifying models while retaining key information. Eigenvectors help identify these directions, and eigenvalues determine the importance of each component.

3. **What is a singular value decomposition (SVD), and why is it important?**

   SVD is a method that decomposes a matrix into three components: U is the left singular vectors, Σ which is singular values and V^T which is the right singular vectors. It's useful in many machine learning tasks like dimensionality reduction, where the singular values indicate the importance of each component. For example, in collaborative filtering for recommendation systems, SVD helps in extracting patterns from large datasets, like user-item interactions, by reducing the matrix to a more manageable form while retaining significant information.

4. **How would you compute the inverse of a matrix? What is its relevance in Machine Learning?**

   The inverse of a A matrix is another matrix A^{-1} such that when multiplied together, they produce the identity matrix. It is primarily used in solving systems of linear equations, a common task in machine learning for linear models like regression. In practice, computing the inverse directly can be computationally expensive, especially for large matrices. Instead, algorithms like gradient descent or the use of pseudoinverses are more commonly used in machine learning to solve optimization problems efficiently.

5. **What is the difference between correlation and causation?**

   Correlation is a statistical relationship between variables, while causation indicates one variable directly affects the other. Correlation doesn't imply causation.

6. **How does gradient descent work? Explain its importance in ML.**

It's like minimizes a function by iteratively adjusting parameters in the direction of the negative gradient and it's essential for training models by optimizing loss functions. Variants like SGD improve efficiency and convergence. Proper learning rate selection is key for performance. Its's essential for training machine learning models by finding the optimal weights that minimize the loss. Variants like SGD wich is Stochastic Gradient Descent amd Mini-batch Gradient Descent and advanced optimizers like Adam make it scalable and efficient for large datasets and deep learning.

7. **What are the types of ML? Discuss each type and give examples on them.**

- Machine learning is divided into several types, but according to their classifications:

First: Based on human supervision:

A) Supervised learning: Uses labeled data to train models (e.g., regression, classification). Examples: spam detection.

B) Unsupervised learning: Finds patterns in unlabeled data (e.g., clustering, dimensionality reduction). Examples: customer segmentation, PCA.

C) Semi-supervised learning: uses a small amount of labeled data with a large amount of unlabeled data. Examples: image classification, speech recognition.

D) Reinforcement learning: Agents learn by interacting with environments to maximize rewards. Examples: robotics, game playing.

Second: Based on their ability to learn gradually

A) Online learning: Updates the model incrementally with each new data point. Example: stock market prediction.

B) Batch learning: Trains the model on the entire dataset at once. Example: training a deep neural network.

Third: Based on comparing new data points with known data points or not.

A) Instance-based learning: Stores training data and makes predictions based on similar instances. Example: k-NN algorithm.

B) Model-based learning: Builds a model that generalizes from training data. Example: decision trees.

8. Explain this code and provide a way to optimize it:

```
SELECT DISTINCT ProductID,
       (
       SELECT SUM(Amount)
        FROM Sales S2
        WHERE S2.ProductID = S1.ProductID
        ) AS TotalSales
FROM Sales S1;
```

- This SQL query retrieves UNIQUE Product IDs from the Sales table S1 and calculates the total sales for each product by summing the Amount for each Product ID. The subquery calculates the total sales for each product.

Optimization: This query is leading to inefficiency. I think a better approach would be to use GROUP BY to calculate the total sales in a single pass.

```
SELECT ProductID, SUM(Amount) AS TotalSales
FROM Sales
GROUP BY ProductID;
```

AHMED MOHAMED KAMAL ZAHR

AIE

LVL200