**Question Two**

**MNIST** is a benchmark dataset comprising 28x28 pixel grayscale images of handwritten digits (0 to 9). It is widely used for digit recognition tasks in machine learning.

**Support Vector Machine (SVM)** is a supervised learning algorithm used for classification and regression tasks. It aims to find the optimal hyperplane that best separates different classes by maximizing the margin.

**Hyperparameter Tuning with Validation Sets:**

**C:** Controls the trade-off between a larger margin and fewer misclassifications on the training set.

**Gamma:** Defines how far the influence of a single training example reaches. A low value implies a far reach and a high value implies a close reach.

**Kernel Type:** SVM can use different kernel functions (e.g., linear, polynomial, radial basis function) that determine the decision boundary complexity.

4. The MNIST dataset was split into training, validation, and test sets. The validation was used to tune hyperparameters while training the model. It aided in assessing the model's performance on unseen data without touching the test set.

**Analysis:**

1. **Hyperparameter Tuning:** Grid search techniques was employed to explore different combinations of hyperparameters (C, gamma, kernel type) efficiently.

2**. Validation Set Usage:** The validation set allowed for evaluating the model's performance during training without overfitting to the test set. It helped in selecting the best hyperparameters that generalize well to unseen data.

3. **Computational Efficiency**: Utilizing validation sets for hyperparameter tuning helped in reducing computational time compared to evaluating on the test set after each hyperparameter iteration.

**Findings:**

1. Proper hyperparameter tuning can significantly enhance the SVM model's accuracy and generalization on unseen data.

2. Tuning the hyperparameters using a validation set, helps one to find the combination that achieves the best performance without overfitting or underfitting.

3. Utilizing validation sets for hyperparameter tuning speeds up the process by reducing the need to repeatedly evaluate on the test set.

4. Tuning hyperparameters helps strike a balance between model complexity and its ability to generalize well to new data.