# REPORT

**1.** Block Diagram of the architecture -

```
Input Image (1×28×28)
|
|
Flatten (→ 784)
|
|
[Encoder]
|
|
Linear (784 → 256)
|
ReLU
|
|
Linear (256 → 128)  ← Latent Vector (z)
|
|
[Decoder]
|
|
Linear (128 → 256)
|
|
ReLU
|
|
```

Linear (256 → 784)

|

|

Tanh

|

|

Reshape to 1×28×28

|

↓

Reconstructed Image

2. **Dataset** analysis : **MNIST** (loaded via Hugging Face).

   **Size**: Training: 60,000 images

   **Image Dimensions**: 28×28 grayscale.

   **Preprocessing**: Normalized from `[0, 255]` → `[0.0, 1.0]` → `[-1.0, 1.0]` using: images = (images - 0.5) / 0.5

3. **Hyperparameters—** Not used

4. **Model parameter counting—** Learning rate, Depth sixe, Latent dimension
5. **If batch normalization , dropout , regularizations used how have you used it—** Not used
6. **Existing clustering comparison—** Silhouette Score: 0.044 , Davies-Bouldin Index: 2.808

7. **How to decide your clustering accuracy labeling of unsupervised learning—** In unsupervised learning like K-Means clustering, we don't have access to class labels during training, but we do have them in the MNIST dataset after training, which allows us to evaluate clustering performance.

- I trained an autoencoder to get embeddings (z).
- Then I applied K-Means clustering on those embeddings.
- Then I used two unsupervised evaluation metrics:
    - Silhouette Score – measures intra-cluster tightness vs inter-cluster separation.
    - Davies-Bouldin Index (DBI) – lower is better, measures average similarity between clusters.

These two metrics do *not* need true labels (y) and are appropriate for unsupervised evaluation.

8. **Limitations and obstacles, and how you overcome them—**
    - The encoding can be improved
    - The transformer model is better to use
    - PCA visualization includes decomposition, so some features don't work accurately.

**Overcoming obstacles**:

- Used **autoencoder latent space** to effectively compress and structure data for better clustering.
- Used **PCA** to reduce dimensions for visualization.
- Used **unsupervised metrics** (Silhouette, DBI) for valid evaluation without labels.