1. What are the main tasks that autoencoders are used for?

**Tasks for Autoencoders:**

* **Dimensionality Reduction:** Autoencoders are used for reducing the dimensionality of data while preserving important features.
* **Anomaly Detection:** They can identify anomalies by learning to reconstruct normal data; deviations from this reconstruction indicate anomalies.
* **Denoising:** Autoencoders can remove noise from data, making it useful for tasks like image denoising.
* **Feature Learning:** Autoencoders can learn meaningful representations of data, which can be used as features for other machine learning tasks.
* **Generative Models:** Variational autoencoders (VAEs) and other generative autoencoders can generate new data samples similar to the training data.

1. Suppose you want to train a classifier, and you have plenty of unlabeled training data but only a few thousand labeled instances. How can autoencoders help? How would you proceed?

**Using Autoencoders for Classification:**

* Autoencoders can be pre-trained on the unlabeled data in an unsupervised manner.
* The encoder's weights can then be used as features for the labeled dataset.
* A classifier (e.g., SVM or a shallow neural network) can be trained on top of these features using the labeled instances.
* This approach leverages the learned representations from the autoencoder to improve classification performance, especially when labeled data is limited.

1. If an autoencoder perfectly reconstructs the inputs, is it necessarily a good autoencoder? How can you evaluate the performance of an autoencoder?

**Autoencoder Evaluation:**

* A perfect reconstruction does not necessarily make a good autoencoder. It may just memorize the data.
* Autoencoder performance can be evaluated by metrics like Mean Squared Error (MSE) for reconstruction loss.
* However, for tasks like anomaly detection, success depends on the model's ability to distinguish anomalies, which requires a thresholding strategy.

1. What are undercomplete and overcomplete autoencoders? What is the main risk of an excessively undercomplete autoencoder? What about the main risk of an overcomplete autoencoder?

**Undercomplete and Overcomplete Autoencoders:**

* **Undercomplete:** These have fewer hidden units in the bottleneck layer than the input layer. The main risk is that they may lose important information during dimensionality reduction.
* **Overcomplete:** These have more hidden units in the bottleneck layer than the input layer. The main risk is overfitting to the training data, which can lead to poor generalization.

1. How do you tie weights in a stacked autoencoder? What is the point of doing so?

**Tying Weights in Stacked Autoencoders:**

* Tying weights means using the transpose of the encoder's weights as the decoder's weights.
* The point is to ensure symmetry and encourage the encoder and decoder to learn complementary features.
* This can lead to better reconstruction and feature learning in deep autoencoder networks.

1. What is a generative model? Can you name a type of generative autoencoder?

**Generative Model:**

* A generative model is a type of model that learns to generate new data points that resemble the training data.
* Variational Autoencoders (VAEs) are a type of generative autoencoder. They learn to generate data samples following a probability distribution.

1. What is a GAN? Can you name a few tasks where GANs can shine?

**GAN (Generative Adversarial Network):**

* GANs consist of two networks: a generator and a discriminator.
* They are used for tasks like image generation, image-to-image translation, and style transfer.
* GANs can generate realistic-looking data samples.

1. What are the main difficulties when training GANs?

**Difficulties When Training GANs:**

* **Mode Collapse:** GANs may converge to generating a limited set of samples rather than diverse data.
* **Training Instability:** GAN training can be unstable, with generator and discriminator competing.
* **Hyperparameter Sensitivity:** GANs are sensitive to hyperparameters and require careful tuning.
* **Evaluation Challenges:** Measuring GAN performance can be challenging.