VAE :

Describe the encoder and decoder networks in a VAE. What are their roles, and what do they output?

What is the **reparameterization trick**, and why is it essential for training VAEs with gradient-based optimization? Illustrate with equations.

Compare the training objective of VAEs with GANs. What does each optimize, and what are the implications for sample quality?

**1.**

**(a)** Explain the architecture of a standard Generative Adversarial Network (GAN). Describe the roles of the generator and discriminator, including the input and output of each network. Use a diagram to illustrate the interaction between the two components.

**(b)** What are the typical loss functions used in GANs for both the generator and discriminator? Write down the mathematical formulation and explain how these loss functions guide the training process.

**(c)** Describe the training procedure of a GAN. Why is GAN training considered unstable? Discuss the techniques that are used to stabilize GAN training.

d) **What are the most commonly used metrics for evaluating the performance of GANs? Compare Inception Score (IS), Frechet Inception Distance (FID), and Precision/Recall for generative models.**

e) **Why is FID generally considered more reliable than IS for measuring GAN output quality? What are the limitations of both?**

f) **Describe a scenario where two GANs have similar FID scores but very different visual results. What might cause this discrepancy?**

g) **Design a metric or method to evaluate the diversity and realism of GAN-generated images in an unlabelled dataset. Justify your approach.**

2.

(a) Illustrate the architecture of the DCGAN generator. Explain how random noise input is transformed into a synthetic image.What activation functions are typically used in DCGANs, and why?

(b)Compare and contrast the architecture of a vanilla GAN with that of a DCGAN (Deep Convolutional GAN). What improvements does DCGAN offer, and why are convolutional layers preferred in image-based GAN tasks?

(c)What are some common challenges faced during the training of DCGANs (e.g., mode collapse, vanishing gradients)?

**(d)** Explain how techniques like batch normalization and LeakyReLU help improve the stability of DCGAN training. What is the significance of removing pooling layers and using strided convolutions instead?

3.

**(a)** Compare the architecture, training methods,loss functions and formulas and performance of Conditional GAN, CycleGAN and StyleGAN and Pix2Pix.   
**(b)** In what scenarios would you prefer one over the other? Support your answer with examples and describe how its architecture differs from a standard GAN. Highlight its use case and any novel components it introduces.

(c )Explain various StyleGAN techniques

4.

(a)What is a Large Language Model (LLM)? Describe how transformer architecture enables LLMs to handle long-range dependencies in text.

**(b)** Compare the encoder-based models (like BERT) with decoder-only models (like GPT). What are their respective strengths and weaknesses?

(c ) Explain the concepts of:

* Zero-shot learning
* Few-shot learning
* In-context learning  
  How are they enabled by LLMs like GPT-3/4?

(d )You are given a chatbot powered by an LLM. What techniques can improve the relevance, safety, and factual accuracy of its responses?

(e ) How reliable are hallucination detection and prevention techniques in LLMs during open-domain generation?

(f )Can synthetic data augmentation (e.g., bootstrapping with smaller models) enhance LLM training efficiency or fairness?