Project 1: **to be handled by Group 1 & Group 5**

Title: *Generative Modeling through Denoising Probabilistic Models*

Objectives: In this project, students will achieve the following gains:

1. Understanding of Diffusion Models:

    1. Gain a comprehensive understanding of diffusion models in its first principle.
    2. Learn how diffusion models transform data into Gaussian noise and then reverse this process for data generation.

2. Implementation Skills:

    1. Develop practical skills in implementing diffusion models using provided code frameworks, particularly in environments like Google Colab.
    2. Enhance programming proficiency by completing specific code segments related to the diffusion process and neural network architectures.

3. Analytical Skills:

    1. Analyze and interpret the behavior of diffusion models through visualization of data distributions and the effects of the diffusion process.
    2. Evaluate model performance using loss curves and output data distributions, improving troubleshooting and optimization abilities.

4. Application of Theoretical Concepts:

    1. Apply theoretical knowledge of stochastic differential equations and probabilistic modeling to data generation tasks.

These objectives will guide learners through a structured exploration of diffusion models, from theoretical understanding to practical analysis.

Project 2: **<u>to be handled by Group 2 & Group 6</u>**

Title: *Creating a 3D Scene Reconstruction using Neural Radiance Field*

Objectives: The goal of this project is to introduce students to Neural Radiance Fields (NeRF) and its application in creating 3D scene reconstructions from 2D images. By the end of this project, students will have the following gains:

1. Understanding of Neural Radiance Fields:

1. Gain a comprehensive understanding of Neural radiance fields and its principle

2. Learn how NeRF can be used to create 3D models from 2D images

2. Implementing Skills:

1. Learn how to develop and test programs with Google Colab for neural network training

2. Implement rays information generation from camera pose and understand the imaging process of physical world

3. Analytical Skills:

1. Evaluate the model performance with loss curve and different image evaluation metrics

2. Analyze the results of NeRF models under different hyperparameter setting and show the effects.

Project 3: **to be handled by Group 3 & Group 7**

Title: *VQVAE for Human Motion Tokenization and Reconstruction*

Objectives: The goal of this project is to develop and evaluate a Vector Quantized Variational Autoencoder (VQVAE) for processing human motion sequences with the following objectives:

1. Understanding VQVAE:

- Learn how VQVAEs convert continuous human motion sequences into discrete integer tokens and reconstruct them.

2. Implementation:

- Implement the VQVAE model using provided code frameworks and datasets, and experiment with different hyperparameters (e.g., embedding sizes, learning rates) to optimize performance.

3. Performance Analysis:

- Assess model performance by visualizing and comparing reconstructed sequences with original data, and analyze the impact of various preprocessing techniques.

Project 4: **<u>to be handled by Group 4 & Group 8</u>**

Title: *Precision Medicine Using Vision Models for Pneumonia Detection and Brain Tumor Classification*

Objectives: Develop and evaluate the performance of a pneumonia detection model / brain tumor classification model based on reference code provided and datasets from online sources.

1. Understand image segmentation and investigate the impact of using image segmentation on the classification performance
2. Analyze the effectiveness of different pre-preprocessing techniques such as image normalization / contract enhancement - on the classification results
3. Experiment with varying learning rates, models and model sizes to understand how the selection affects the classification performance
4. Medical data often has smaller amounts of data (investigate the reasons) and then explore data augmentation techniques to overcome this challenge of limited medical data and evaluate the impact on the model performance
5. Using the reference code as example, students can also explore other datasets (not limited to pneumonia or brain tumor classification)