Assignment:

You have been asked to develop an image classification model using an existing pre-trained model.

1) Enumerate three design choices for your architecture.

Three of the design choices in this context could be:

1. Shallow Fine-tuning (training only the prediction head/final classification layer and keeping the remaining model frozen)
2. Deep Fine-tuning (training some more layers closer to the prediction head while keeping the remaining layers frozen)
3. Training from scratch (training the pre-trained model completely from scratch, on the available target dataset)

2) Write down the merit and demerits of the design choices you have come up with.

1. **Shallow Fine-tuning**
   Merits: Fast and computationally efficient. Leverages features from the pre-trained model to the maximum extent. Since only the prediction head is trained, the risk of overfitting is minimized.
   Demerits: May not achieve same level of accuracy as deep/full fine-tuning, especially if the target domain is significantly different from that of the data used for pre-training. It allows for very limited customization and may not adapt well to the new data in target domain, as it relies heavily on the quality and relevance of the features learned by the pre-trained model.

2. **Deep Fine-tuning**
   Merits: Helps achieve the right balance between adaptation to target domain and computational efficiency, in comparison to other approaches. Choosing the right layers from the pre-trained model for fine-tuning can better generalize to the new dataset, without risk of overfitting.
   Demerits: Can lead to complexities in design as deciding which layers to fine-tune requires target domain knowledge and careful consideration & experimentation. If not done right, can lead to suboptimal performance.

3. **Training from scratch**
   Merits: Offers high flexibility and control in model architecture, parameter initialization and fine-tuning of hyper-parameters, allowing for customization tailored specifically to the target domain. Eliminates any biases/assumptions from the pre-trained model.
   Demerits: Can be computationally expensive and time-consuming. Often requires substantial amount of labeled data to achieve desired performance, which may not always be available. Models trained from scratch may struggle to generalize well to unseen data and overfit the training data, especially if the training dataset available was extremely limited.

3) What is a better choice: Fine tuning the shallower layers or the deeper layers? Justify in the context of image classification problem.

While optimal choice depends on the specific target domain/dataset and pre-trained model being used, fine-tuning the deeper layers is generally a better choice than fine-tuning shallower layers.

Deeper layers capture more abstract and specialized features that are generally more task specific and fine-tuning them allows the model to adapt well to the target domain's specific features and improve overall performance. On the contrary, shallower layers capture more general features (e.g.; edges, textures in case of image processing) which are already well learned in the pre-trained model and attempting to fine tune them may not provide significant performance gain while instead possibly leading to loss of knowledge gained by the pre-trained model and overfitting to the target dataset used for training.