Unit 1 - Foundations of Deep Learning (25 Questions)

A. Basic Concepts (1–7)

- Define Machine Learning. How is it different from traditional programming?
- What is Deep Learning, and how does it relate to Machine Learning?
- Explain the terms **bias** and **variance** with examples.
- What is the **bias-variance trade-off**? How does it impact model performance?
- Define **hyperparameters** and provide three examples commonly used in deep learning.
- Differentiate between **underfitting** and **overfitting**.
- What is **regularization** in deep learning, and why is it used?

B. Limitations and History (8–11)

- Mention at least three limitations of traditional machine learning techniques.
- Trace the history of deep learning from its origins to modern applications.
- Who are some key contributors to the development of deep learning?
- How did advancements in hardware impact the rise of deep learning?

C. Advantages and Challenges (12–15)

- List three major advantages of deep learning over classical machine learning.
- Describe at least three challenges in deploying deep learning systems.
- Why does deep learning require large amounts of data and computation?
- Explain the **black-box** nature of deep learning and its implications.

D. Representation Learning (16–18)

- What is **representation learning**, and why is it crucial in deep learning?
- How does deep learning learn hierarchical features from raw data?

- Explain with an example how feature extraction differs in ML vs. DL.

E. Understanding Deep Learning (19–21)

- Describe how deep learning can be understood using three illustrative figures.
- What are **common architectural principles** of deep networks?
- How do layers, neurons, and activation functions contribute to a network's capability?

F. Architecture & Applications (22–25)

- What factors influence the design of a deep learning architecture?
- Compare and contrast shallow vs. deep neural networks.
- List five real-world applications of deep learning with brief descriptions.
- How is deep learning being used in healthcare, autonomous systems, or natural language processing?

Unit 2 - Introduction to Neural Networks (25 Questions)

A. Fundamentals of Neural Networks (1–5)

- What is a **biological neuron** and how does it inspire artificial neural networks?
- Explain the structure and function of a **perceptron**.
- What is a **multilayer feed-forward neural network**, and how does it differ from a single-layer perceptron?
- Define **forward propagation** and explain its role in neural networks.
- Describe the process and purpose of **backpropagation** in training neural networks.

B. Activation Functions (6–10)

- Compare **linear** and **non-linear** activation functions. Why is non-linearity important?
- Describe the **Sigmoid** activation function and its limitations.

- What are the advantages of using **ReLU (Rectified Linear Unit)** over Sigmoid or Tanh?
- Define and compare **Tanh** and **Hard Tanh** functions.
- What is the purpose of the **Softmax** activation function and where is it commonly used?

C. Loss Functions (11–15)

- What is a **loss function** in neural networks? Why is it important?
- Differentiate between **loss functions for regression** and **classification**.
- Give examples of **loss functions** used for **regression problems**.
- Explain **cross-entropy loss** and when it is used.
- What is a **reconstruction loss function** and in which tasks is it typically applied?

D. Hyperparameters (16–19)

- Define the term **hyperparameter** in the context of neural networks.
- How does the **learning rate** affect neural network training?
- What is the role of **momentum** in gradient-based learning?
- Explain the concepts of **regularization** and **sparsity** in deep networks.

E. Deep Feedforward Networks & XOR (20–23)

- Why can't a single-layer perceptron solve the **XOR problem**?
- How do **hidden units** help in solving non-linear problems like XOR?
- Describe how **cost functions** guide the training of a deep neural network.
- Outline the steps involved in **gradient-based learning** using backpropagation.

F. Miscellaneous (24–25)

- What is the difference between **training error** and **generalization error**?
- Explain the relationship between **number of hidden layers**, **model complexity**, and

computational cost in deep neural networks.

Unit 3 - Convolutional Neural Networks (CNNs)

Introduction to CNN (1–3)

- What is a Convolutional Neural Network (CNN), and how does it differ from a traditional feedforward neural network?
- Explain two real-world applications of CNNs in computer vision.
- Why are CNNs considered more efficient than fully connected networks for image-related tasks?

CNN Architecture Overview (4–6)

- Describe the general architecture of a CNN model.
- What are the main components of a CNN pipeline, from input to output?
- How does feature extraction in CNNs differ from handcrafted feature extraction methods?

The Basic Structure of a Convolutional Network (7–9)

- Define convolution operation in the context of CNNs. Provide a simple numerical example.
- What is the role of filters (kernels) in CNNs?
- Explain the concept of receptive field in convolutional networks.

Padding, Strides, and Typical Settings (10–13)

- What is padding in CNNs, and why is it used? Compare "valid" and "same" padding.
- Define stride. How does increasing stride affect the output size?
- List some typical settings for kernel size, stride, and padding in standard CNN architectures.

ReLU Layer (14–15)

- What is the ReLU activation function, and why is it preferred in CNNs?

- Compare ReLU with sigmoid and tanh activation functions in terms of efficiency and gradient issues.

Pooling Layer (16–18)

- What is the purpose of pooling layers in CNNs?
- Differentiate between max pooling and average pooling.
- How does pooling contribute to translation invariance?

Fully Connected Layers (19–20)

- Explain the role of fully connected (dense) layers in CNNs.
- Why are fully connected layers usually placed at the end of the CNN architecture?

Interleaving between Layers (21–22)

- Explain how convolution, activation, and pooling layers are interleaved in CNN architectures.
- Provide an example sequence of layers for a simple CNN model.

Local Response Normalization (LRN) (23–24)

- What is Local Response Normalization in CNNs?
- How does LRN improve the generalization of CNN models?
- Compare LRN with Batch Normalization in terms of purpose and effectiveness.

Training a Convolutional Network (25)

- Outline the main steps involved in training a CNN, from forward pass to backpropagation.

Unit 4 - Recurrent and Recursive Neural Networks

Unfolding Computational Graphs (1–2)

- What does “unfolding” mean in the context of recurrent neural networks?
- Explain how computational graphs are used to represent RNNs during training.

Recurrent Neural Networks (RNNs) (3–5)

- Describe the architecture of a simple recurrent neural network.
- What types of tasks are RNNs best suited for compared to feedforward networks?
- Explain the vanishing gradient problem in RNNs.

Bidirectional RNNs (6–7)

- What is a Bidirectional RNN, and how does it differ from a standard RNN?
- Give one advantage and one limitation of Bidirectional RNNs.

Encoder-Decoder Sequence-to-Sequence Architectures (8–10)

- Explain the role of the encoder and decoder in sequence-to-sequence models.
- How are encoder-decoder models applied in machine translation tasks?
- What is the role of attention in improving encoder-decoder architectures?

Deep Recurrent Networks (11–12)

- What makes a recurrent network "deep"?
- Discuss one benefit and one drawback of deep RNN architectures.

Recursive Neural Networks (13–15)

- How does a recursive neural network differ from a recurrent neural network?
- Give an example of a real-world application where recursive neural networks are useful.

The Challenge of Long-Term Dependencies (16–17)

- Why do standard RNNs struggle with long-term dependencies?
- How does backpropagation through time (BPTT) worsen the vanishing/exploding gradient problem?

Echo State Networks (18–19)

- What is the key idea behind Echo State Networks (ESNs)?
- How does the concept of a "reservoir" help in ESNs?

Leaky Units and Multiple Time Scales (20–21)

- What are leaky units, and how do they help model long-term dependencies?
- Explain how multiple time scales can be handled in recurrent architectures.

Long Short-Term Memory (LSTM) and Gated RNNs (22–23)

- What are the main components (gates) of an LSTM unit, and what is their function?
- How do Gated Recurrent Units (GRUs) differ from LSTMs?
- Compare the performance of LSTM, GRU, and vanilla RNN in handling long sequences.

Optimization for Long-Term Dependencies (24)

- Describe two optimization strategies to mitigate vanishing gradients in RNNs.

Explicit Memory (25)

- What is meant by explicit memory in neural networks, and how does it differ from implicit memory in RNNs?

Unit 5 - Deep Generative Models & Reinforcement Learning

Introduction to Deep Generative Models (1–3)

- What is a generative model? How does it differ from a discriminative model?
- Explain the role of probability distributions in generative modeling.
- Give two practical applications of deep generative models in real-world tasks.

Boltzmann Machine (4–6)

- Describe the architecture and working principle of a Boltzmann Machine.
- What is the role of stochastic units in a Boltzmann Machine?
- Explain the limitation of Boltzmann Machines in large-scale learning tasks.

Deep Belief Networks (DBNs) (7–9)

- What is a Deep Belief Network, and how is it constructed?

- Differentiate between Restricted Boltzmann Machines (RBMs) and Deep Belief Networks (DBNs).
- Mention two applications of DBNs in pattern recognition or feature learning.

Generative Adversarial Networks (GANs) (10-13)

- Explain the two main components of a GAN and their roles.
- How do GANs learn through the minimax optimization game?
- Describe two challenges faced in training GANs.
- List some real-world applications of GANs in industry and research.

Introduction to Deep Reinforcement Learning (14–16)

- Define deep reinforcement learning. How does it extend traditional reinforcement learning?
- Explain the significance of deep neural networks in reinforcement learning.
- Give an example of a real-world system where deep reinforcement learning is applied.

Markov Decision Process (MDP) (17–19)

- What are the key components of a Markov Decision Process (MDP)?
- Explain the Markov property in the context of reinforcement learning.
- Differentiate between deterministic and stochastic policies in MDPs.

Basic Framework of Reinforcement Learning (20–22)

- Draw and explain the basic framework of reinforcement learning with agent-environment interaction.
- Define reward, policy, and value function in reinforcement learning.
- Explain the difference between model-based and model-free reinforcement learning.

Challenges of Reinforcement Learning (23–24)

- What is the exploration vs. exploitation dilemma in reinforcement learning?
- Explain the problem of sparse rewards in reinforcement learning.