Section A: Fundamentals of Deep Learning

Q1. What is Deep Learning?

Deep learning is a part of machine learning that uses neural networks with many layers to learn complex patterns.
It's called "deep" because it has multiple hidden layers compared to traditional models.

Q2. Key Components of Deep Learning

The main components of a deep learning model are:

- **Layers:** input, hidden, and output layers.
- **Activation functions:** like ReLU or Sigmoid to add non-linearity.
- **Loss function:** measures how far predictions are from the actual results.
- **Optimizer:** updates weights to reduce the loss (e.g., SGD, Adam).

Q3. Neuron & Perceptro

A neuron multiplies inputs by weights, adds a bias, and passes the result through an activation function.
The perceptron formula is:
$\mathbf{y = f(\Sigma(w_i x_i) + b)}$
When many perceptrons are connected together, they form a neural network.

Q4. Hierarchical Representations

In deep learning, lower layers learn simple features like edges or textures, while higher layers learn more detailed ones like shapes, objects, or faces.
This helps the model understand data in a structured way.

Q5. Backpropagation

Backpropagation finds the error in predictions and adjusts the weights by sending this error backward through the network.
It helps the model learn and reduce mistakes step by step.

Q6. Non-Convex Functions

Non-convex functions have many local minima and saddle points, which makes it hard for optimizers to find the global best solution.

Q7. Training & Optimization

Training happens in steps:

1. **Forward pass:** predict the output.
2. **Loss calculation:** find the difference from the true value.
3. **Backward pass:** update the weights using the optimizer.
   Techniques like **dropout**, **batch normalization**, and **learning rate scheduling** help improve performance.

Q8. Challenges in Deep Learning

Deep learning needs large amounts of data and high computing power.
Models can be complex and hard to explain, so clean data and good tuning are important for better results.

Section B: Frameworks & Implementation

Q9. Deep Learning Frameworks

Common frameworks include:

- **TensorFlow:** used for large-scale applications.
- **PyTorch:** flexible and easy for research.
- **Keras:** simple, user-friendly API built on top of TensorFlow.

Q10. Building Models with Keras & TensorFlow

Steps to build a neural network:

1. **Define layers** using `Sequential()`.
2. **Compile** the model by choosing the optimizer and loss function.
3. **Train** the model using `fit()` and check accuracy using `evaluate()`.

Q11. Data Preprocessing & Features

- **Data preprocessing:** cleaning and scaling data before training.
- **Feature engineering:** creating useful input features manually.
- **Feature learning:** when the model learns features automatically during training.
  These steps help improve accuracy and performance.

Section C: Image Classification Concepts

Q12. Image Classification

Image classification means teaching a model to recognize and label images.
For example, identifying cats vs. dogs or detecting diseases from X-rays.

Q13. ImageNet

ImageNet is a large dataset of labeled images used for training deep learning models.
It became famous because the ImageNet Challenge pushed huge progress in computer vision.

Q14. Perceptron for Binary Classification

A single-layer perceptron predicts two classes using the formula:
$\mathbf{y = step(\Sigma(w_i x_i) + b)}$
If the sum is greater than 0, output is 1; otherwise, 0.

Q15. Model Interpretability

Deep learning models are called “black boxes” because we can’t easily see how they make decisions.
Methods like **Grad-CAM** help show which image areas influenced a prediction.

Q16. Adversarial Examples

These are tiny, invisible changes in input images that can fool the model into making wrong predictions.
Training with such examples makes models more robust.

Q17. Transfer Learning

Transfer learning means using a pre-trained model on a new problem with less data.
Popular models include **VGG16** and **ResNet50**.

Section D: Applications of Deep Learning

Q18. Applications in Data Science

Deep learning is used in speech recognition, healthcare image diagnosis, and natural language processing (NLP) like text translation and sentiment analysis.

Q19. Employee Attrition Case Study

a) It’s a **classification** problem.
b) A small **ANN** with a few dense layers can be used.
c) The **binary cross-entropy** loss function fits best.
d) Results help HR predict and prevent employee turnover.