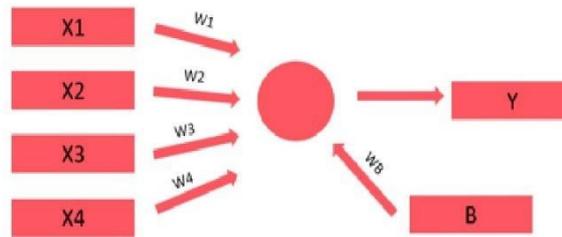Perceptron Example

a)

A perceptron takes inputs (example: jacket = 1, umbrella = 0), multiplies them by weights (importance), adds a bias, and calculates a weighted sum.

b) If the weighted sum exceeds a value >=0 (go out); otherwise, <0 (stay in).

For example:

Output = w1*x1 + w2*x2 + w3*x3 + w4*x4 - b

If Output >=0

→ Go to park

Else

→ Stay at home

Long Answer Questions with Answers

Q1. **Explain neural networks. Describe the three layers of neural networks.**

Answer:

An Artificial Neural Network (ANN) is a model inspired by the human brain. It consists of layers of interconnected nodes ("neurons") that process information. A neural network is essentially a system of organizing machine learning algorithms to perform certain tasks. It is a fast and efficient way to solve problems for which the dataset is very large, such as in images.
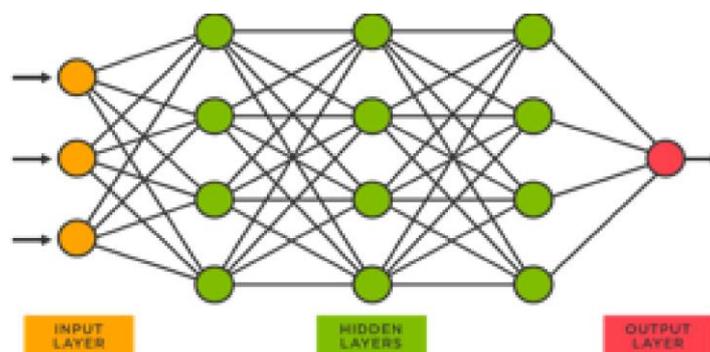
Layer 1: Input Layer

- The job of an input layer is to acquire data and feed it to the Neural Network. No processing occurs at the input layer.

Layer 2: Processing/Hidden Layer

- Each node of these hidden layers has its own machine learning algorithm which it executes on the data received from the input layer.
- Each node Learns patterns, relationships in the input received.
- Why "Hidden"? Not directly visible; it processes internal computations.
- There can be multiple hidden layers in a neural network that depends upon the complexity of the function.

Layer 3: Output Layer
- Produces final prediction/output.
- The last hidden layer passes the final processed data to the output layer which then gives it to the user as the final output.
- Similar to the input layer, output layer too does not process the data which it acquires.

Q2. Identify the type of learning (supervised, unsupervised, reinforcement learning) and justify the following case studies most likely based on?
Case Study 1: A company wants to predict customer churn based on past purchasing behaviour, demographics, and customer interactions. They have a dataset with labelled examples of customers who churned and those who did not.

Case Study 2: A social media platform wants to group users based on their interests and behaviour to recommend relevant content. They have a large dataset of user interactions but no predefined categories.
Case Study 3: An autonomous vehicle is learning to navigate through a city environment. It receives feedback in the form of rewards for reaching its destination safely and penalties for traffic violations.
Case Study 4: A healthcare provider wants to identify patterns in patient data to personalize treatment plans. They have a dataset with various patient attributes but no predefined labels indicating specific treatment plans.

Answer:

Case Study 1: Predicting customer churn
- Type of Learning: Supervised Learning
- Justification: The company has a labelled dataset with examples of customers who churned and those who did not. Since the goal is to predict a labelled outcome (churn or not) based on input features purchasing behaviour, this is a supervised learning scenario.

Case Study 2: Grouping users for content recommendation
- Type of Learning: Unsupervised Learning
- Justification: The goal is to group users based on their behaviour and interests without predefined categories or labels. This task involves finding patterns or clusters in the data, which is characteristic of unsupervised learning.

Case Study 3: Autonomous vehicle learning to navigate
- Type of Learning: Reinforcement Learning
- Justification: The autonomous vehicle learns by interacting with the environment, receiving rewards for good behaviour (reaching the destination safely) and penalties for bad behaviour (traffic violations). This feedback-based trial-and-error approach is typical of reinforcement learning.

Case Study 4: Identifying patterns in patient data
- Type of Learning: Unsupervised Learning
- Justification: The healthcare provider aims to find hidden patterns in patient data without predefined labels or outcomes. This suggests clustering or dimensionality reduction to support treatment personalization, which falls under unsupervised learning.

Q3. Identify the type of learning (supervised, unsupervised, reinforcement learning) and justify the following case studies most likely based on?
Case Study 1: An online learning platform wants to predict student performance in upcoming tests based on their previous quiz scores, course engagement data, and demographic information. The platform has labelled data indicating whether students passed or failed in past tests.

Case Study 2: A factory installs sensors on machines to collect data such as temperature, vibration, and noise levels. They want to detect abnormal machine behaviour that could indicate a malfunction. They do not have labelled examples of failures but want to monitor anomalies in real-time.

Case Study 3: A farming organization wants to optimize irrigation by using a drone that learns to adjust water levels based on crop health, weather conditions, and soil moisture. The drone receives a reward when crop yield improves and a penalty when overwatering occurs.

Case Study 4: A retail chain wants to segment its customers based on their purchasing habits to tailor marketing campaigns. They have large amounts of transaction data but no predefined customer segments.

Answer:

Case Study 1: Predicting student performance
- Type of Learning: Supervised Learning
- Justification: The dataset includes labelled outcomes (e.g., passed or failed), and the goal is to predict a specific outcome based on input features. This clearly fits the supervised learning model, where the model is trained on known inputs and outputs to make future predictions.

Case Study 2: Detecting abnormal machine behaviour
- Type of Learning: Unsupervised Learning
- Justification: Since there are no labelled outcomes (i.e., no specific examples of what constitutes a failure), the goal is to identify anomalies or patterns in sensor data. This is a typical application of unsupervised learning, especially using techniques like anomaly detection or clustering.

Case Study 3: A drone learning irrigation optimization
- Type of Learning: Reinforcement Learning
- Justification: The drone receives feedback in the form of rewards (high yield) or penalties (overwatering) and adjusts its actions accordingly. This trial-and-error learning with a focus on maximizing cumulative rewards is a characteristic of reinforcement learning.

Case Study 4: Segmenting customers based on purchase behaviour
- Type of Learning: Unsupervised Learning
- Justification: The objective is to group customers based on similarities in purchasing habits without existing labels or segments. This is a classic

clustering problem in unsupervised learning, often used for customer segmentation in marketing.

Q4. Explain the Perceptron Model with the given context. (Illustrative Model)

Context: Decide whether to go outside, based on weather-related inputs.

Factors:
- Do I have a jacket?
- Do I have an umbrella?
- Is it sunny now?
- What is the weather forecast later?

Answer:

Goal: Decide whether to go outside or prepare for the weather

Step-by-Step Conversion to Perceptron

Step 1: Define the Inputs

Question	Variable	Case 1 Sample Answer	Case 2 Sample Answer
Do I have a jacket?	X1	1 (Yes)	0 (No)
Do I have an umbrella?	X2	0 (No)	1(Yes)
Is it Sunny now?	X3	1(Yes)	0 (No)
What is the weather forecast for later? (Good(No rain)- Yes, Not Good(rain) - No)	X4	0 (No)	1(Yes)

Step 2: Assign Weights and Bias

Weights Importances	Sample Example Weights
W1 (having a jacket helps)	1.5
W2 (umbrella more important in rain)	1.0
W3 (it is Sunny now is most important)	3.0
W4 (weather to be ok is next most important)	2.5
Bias (B) (Note: Bias value can be higher or lower value, Higher bias value Favors to be cautious about weather,	4.0

lower bias value Favors going outside) Here we have taken +4.0	

Step 3: Apply the Perceptron Formula
Case 1:
Result = X1*W1 + X2*W2 + X3*W3 + X4*W4 - B
Result= 1*1.5 + 0*1.0 + 1*3.0 + 0*2.5 - 4.0
Result= 1.5+0.0+3.0+0.0 – 4.0 = +0.5

Case 2:
Result = X1*W1 + X2*W2 + X3*W3 + X4*W4 - B
Result= 0*1.5 + 1*1.0 + 0*3.0 + 1*2.5 - 4.0
Result= 0.0 + 1.0 + 0.0 + 2.5 – 4.0 = –0.5
Step 4: Apply Activation Function (Step Function)
Output= if Result >= 0 Go Outside
        if Result < 0 Don't Go Outside
Case 1:
As Result = 0.5   > =0 → Go outside

Case 2:
As Result = − 0.5   < 0 → Don't go outside

Q5. Identify the type of model (classification, regression, clustering, association model) and justify the following case studies most likely based on?

Case Study 1: A bank wants to predict whether a loan applicant will "default" or "non-default" on their loan payments. They have a dataset containing information such as income, credit score, loan amount, and employment status.

Case Study 2: A real estate agency wants to predict the selling price of houses based on various features such as size, location, number of bedrooms, and bathrooms. They have a dataset containing historical sales data.

Case Study 3: A marketing company wants to segment its customer base into distinct groups based on purchasing behaviour for targeted marketing

campaigns. They have a dataset containing information such as purchase history, frequency of purchases, and amount spent.

Case Study 4: A grocery store wants to identify associations between different products purchased by customers to understand which products are commonly bought together. They have a transaction dataset containing records of items purchased together during each transaction.

Answer:

Case Study 1: Predicting Loan Default
- Type of Model: Classification
- Justification: The goal is to predict a categorical outcome — whether a customer will "default" or "non-default" on a loan. Since the outcome is binary (two classes), this is a classification problem.

Case Study 2: Predicting House Prices
- Type of Model: Regression
- Justification: The objective is to predict a continuous numeric value — the selling price of a house based on various features such as size, location, number of bedrooms, and bathrooms This falls under regression model.

Case Study 3: Customer Segmentation
- Type of Model: Clustering
- Justification: The goal is to group customers into segments based on behaviour, without predefined labels. This is a clustering task, a type of unsupervised learning.

Case Study 4: Product Association Analysis
- Type of Model: Association Model
- Justification: The task is to identify relationships between items purchased together, such as "customers who buy bread also buy butter." This is best addressed with association rule, making it an association model.

Q6. Identify the type of model (classification, regression, clustering, association model) and justify the following case studies most likely based

on?

Case Study 1: An investment firm wants to predict the future stock price of a company based on historical stock data, trading volume, market indicators, and financial reports.

Case Study 2: A social media platform wants to identify communities of users with similar interests and interactions for better content personalization. They have data on likes, comments, shares, and followed pages.

Case Study 3: A school wants to determine whether students will pass or fail a standardized exam based on features such as attendance, homework completion rate, quiz scores, and participation.

Case Study 4: An agricultural analytics company wants to find combinations of fertilizers and crop types that are frequently used together across different farms, to optimize supply chain and product bundling.

Answer:

Case Study 1: Predict the future stock price

- Type of Model: Regression

- Justification: The goal is to predict a continuous numerical value, the future stock price, based on past and present data. This clearly represents a regression problem.

Case Study 2: Identify communities of users

- Type of Model: Clustering

- Justification: The task is to group users based on patterns in their behaviour without predefined labels. This is a clustering problem used to uncover structure in user interaction data.

Case Study 3: Whether students will pass or fail.

- Type of Model: Classification

- Justification: The goal is to predict a categorical outcome (pass or fail), making this a classification problem.

Case Study 4: Find combinations of fertilizers and crop type

- Type of Model: Association Model

- Justification: The objective is to discover associations or frequent patterns among items (fertilizers and crops) used together, which is a typical use case for an association model.

Q7. Explain the Perceptron Model with the given context. (Illustrative Model)

Context: A manager is deciding whether to approve a work-from-home request from an employee.

Factors:

Does the employee perform well when working remotely?
Are there any upcoming team meetings or collaborative projects?
Does the company's policy support remote work?
Is it beneficial for both the employee and the company?

Answer:

Goal: whether to approve a work-from-home request or not

Step-by-Step Conversion to Perceptron

Step 1: Define the Inputs

We'll define each factor as a binary input (1 for Yes/True, 0 for No/False)

Question	Variable	Case 1 Sample Answer	Case 2 Sample Answer
Does the employee perform well when working remotely?	X1	0 (No)	1 (Yes)
Are there any upcoming team meetings or collaborative projects?	X2	0 (No)	0 (No)
Does the company's policy support remote work?	X3	1(Yes)	1(Yes)
Is it beneficial for both the employee and the company?	X4	0(No)	0(No)

Step 2: Assign Weights and Bias

Assign sample weights (w1 to w4) to reflect the importance of each factor. For example:

Weights Importances	Sample Example Weights
W1 (performance remotely is important)	0.6
W2 (collaboration can affect approval, but less critically)	0.4
W3 (policy compliance matters)	0.5
W4 (mutual benefit is most important)	0.7
Bias (B) (Note: Bias value can be higher or lower value, Higher bias value Favors to be Strict in permitting work from	1.0

home, lower bias value Favors to allow work from home) Here we have taken +4.0

Step 3: Apply the Perceptron Formula
Case 1:
Result = X1*W1 + X2*W2 + X3*W3 + X4*W4 − B
Result= 0*0.6 + 0*0.4 + 1*0.5 + 0*0.7 – 1.0
Result= 0.0+0.0+0.5+0.0 – 1.0 = − 0.5

Case 2:
Result = X1*W1 + X2*W2 + X3*W3 + X4*W4 - B
Result= 1*0.6 + 0*0.4 + 1*0.5 + 0*0.7 – 1.0
Result= 0.6+0.0+0.5+0.0 – 1.0 = + 0.1

Step 4: Apply Activation Function (Step Function)
Output= if Result >= 0 Allow to work from home
        If Result < 0 Don't allow to work from home
Case 1:
`As Result = − 0.5 (i.e < 0)`
Hence, Employee request to work from home is Not Approved.
Case 2:
As Result = + 0.1 (i.e >= 0)
Hence, Employee request to work from home is Approved.