4.2 Machine learning algorithms

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS data preprocessing • data leakage • linear regression • k-nearest neighbours • artificial neural network • confusion matrix

Objective

Build the skills to answer HL exam questions on **machine learning algorithms** – data preprocessing, linear regression, k-nearest neighbours, neural networks, and precision and recall.

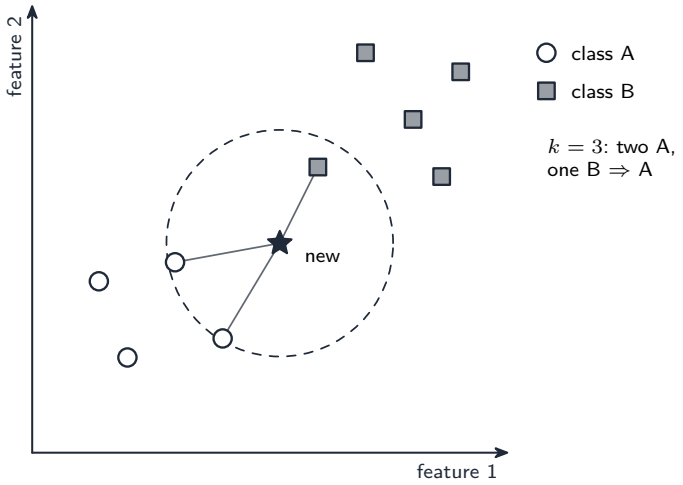
You must be able to:

- describe the steps of **data preprocessing** and spot **data leakage**
- predict with a **linear regression** line
- classify a point by **k-nearest neighbours**
- describe the structure and training of an **artificial neural network**
- calculate precision and recall from a **confusion matrix**

1 Key knowledge and worked examples

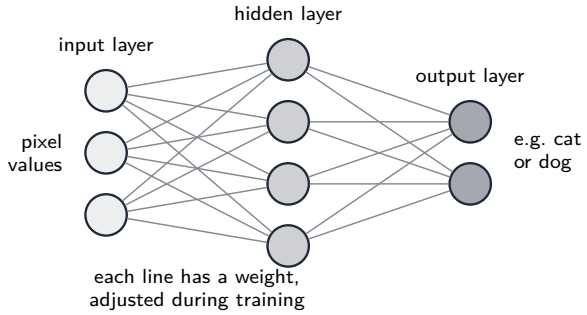
Study these first. Each one shows the method for a question type used later.

■ Worked example: k-nearest neighbours



1. Find the distance from the new point to every training point.
2. Take the k nearest: here B (0.89), A (1.12), A (1.17).
3. Majority class: **A**. With $k = 1$ it would be **B**: the choice of k matters; an odd k avoids ties.

■ Key knowledge: neural networks



- Each connection has a **weight** ; each node sums its weighted inputs and passes the result on.
- Training: compare the output with the label, then adjust every weight slightly to reduce the error; repeat over many examples.

■ **Worked example: precision and recall**

	Actually positive	**Actually negative**
predicted positive	TP 4	FP 10
predicted negative	FN 1	TN 85

$$\text{precision} = \frac{TP}{TP + FP} = \frac{4}{4 + 10} \approx 0.29$$

$$\text{recall} = \frac{TP}{TP + FN} = \frac{4}{4 + 1} = 0.80$$

Recall: of the real positives, how many were found. Precision: of those flagged, how many were right.

2 Practice

2.1 State the preprocessing step for each: (i) removing a row where age is 250; (ii) scaling income and age to 0–1; (iii) dropping a customer ID column. [3]

2.2 A best-fit line is $y = 2.4x + 15$. Predict y when $x = 20$. [2]

2.3 A classifier has TP = 45, FP = 5, FN = 15, TN = 135. Calculate (i) accuracy; (ii) precision; (iii) recall. [3]

3 Exam-style questions

3.1 Which algorithm is unsupervised? [1]

- **A** linear regression
- **B** k-nearest neighbours
- **C** k-means clustering
- **D** decision tree

3.2 What is changed during the training of a neural network? [1]

- **A** the number of input nodes
- **B** the weights of the connections
- **C** the training labels
- **D** the test data

3.3 A cancer screening test should miss as few real cases as possible. Which measure should be high? [1]

- **A** precision
- **B** recall
- **C** training speed
- **D** number of features

3.4 An app predicts whether a plant is healthy from leaf photos.

(a) Describe **three** preprocessing steps for the photos and their labels. [3]

(b) A developer adds “date the plant died” as a feature, and test accuracy jumps to 99%. Explain why this is a problem. [2]

(c) Explain why a convolutional neural network suits this task. [2]

(d) On 200 test photos the model gives TP = 50, FP = 30, FN = 10, TN = 110, where positive means “diseased”. Calculate the precision and recall, and state which matters more to a gardener who wants to treat every sick plant. [4]