Section 1: Constant acceleration

Students' strengths and common misconceptions

The table below outlines the areas in which most students do well and the common mistakes and misconceptions across the topics listed.

	Strengths	Common mistakes
Vectors and Scalars	Most students will already be able to state some vectors and scalars and recall the definition of a vector.	At GCSE applying mathematics to vector quantities is taught in a huge variety of ways. Some learners will have covered the topic with full mathematical detail while others will have been given a scaffolded approach that works for GCSE but does not give the full picture. These formulaic methods are often deeply entrenched and must be challenged at KS5.
Using Equations	Students will be familiar with applying equations and know some of the equations being used. Most, but not all, candidates will be confident with re-arranging equations, particularly if your centre requires B grades in GCSE Maths and Physics to take the course. Often students who have chosen the course rather *like* using equations, as this remains a core skill at GCSE.	As the equations being used for uniform motion are all similar and contain four rather than three variables the often-taught GCSE approach of 'find an equation in the formula sheet that fits and plug in the numbers' tends to fail. Likewise, the rearrangement technique using a triangle no longer applies. Students struggle especially with distinguishing initial and final velocity. The issues with use of negative numbers discussed above apply here.

Teaching ideas

Objectives

- Revise vectors and scalars.
- Assign + and – signs to vector quantities, based on direction.
- Perform calculations using the equations for uniformly accelerated motion.

Starter activities

Vectors and scalars

This activity is designed to aid recall of GCSE material and stimulate discussion of the definition of a vector. It should be relatively unchallenging and could be used with weaker learners to build confidence.

Sort the quantities into vectors and scalars.
Explain your reasoning for each one.

Mass, Weight, Force, Speed, Velocity, Acceleration,
Distance, Displacement, Energy, Time

A Tale of Two Cities

This is a challenging activity designed to really make learners think about the vector nature of velocity. It should really highlight vectors misconceptions from GCSE. It also provides revision of graphs, which are covered in the next topic.

The cities of Principia and Mathematica are connected by a straight 100km long road.

1. Cars A and B leave Mathematica at the same time. Car A travels at 60 km/hr while car B travels at 40 km/hr. What is the difference in time between their arrivals in Principia?
2. Car C starts in Mathematica, travelling at 60 km/hr. Car D starts in Principia, travelling at 40 km/hr. They leave at the same time.
   - **a** Draw a diagram to show where both cars are after half an hour.
   - **b** When and where do the cars pass each other?
   - **c** There are at least two ways of solving part B. Find another way of getting the solution.
   - **d** Sketch displacement time graphs for both cars on the same axis. Consider their starting points and gradients carefully. What do you notice?
   - **e** Extension – both cars turn around when they reach their respective cities but maintain the same speeds. Have their velocities changed? When will they next pass? When will C **overtake** D (same position travelling in the same direction)?

Section 2: Motion graphs

Students' strengths and common misconceptions

The table below outlines the areas in which most students do well and the common mistakes and misconceptions across the topics listed.

	Strengths	Common mistakes
Velocity- and Displacement-Time Graphs	Students will be familiar with the graphs from GCSE and probably already recall the rules for interpreting them.	Students frequently mix up displacement and velocity graphs. Students will be unfamiliar with graphs going below the x-axis
Calculating Areas and Gradients	Has been covered at GCSE and covered in some detail in Maths GCSE.	Many students find this one of the most challenging parts of GCSE. Methods taught are often inconsistent with Maths, leading to confusion and difficulty applying skills learnt.
y= mx + c	Introduced in Maths GCSE	Conceptually very challenging as Maths treat y and x as abstractions whereas they are typically concrete values in science. Requires re-visiting several times before most students grasp it.

Section 3: Weight and mass

Students' strengths and common misconceptions

The table below outlines the areas in which most students do well and the common mistakes and misconceptions across the topics listed.

	Strengths	Common mistakes
Weight and Mass	Students tend to find using $W = mg$ relatively straightforward as it is a simple three variable equation.	Whilst students are good at using $W = mg$ they often neglect to do so. Through a combination of carelessness and misconception GCSE students mix weight and mass, or forget to convert, with alarming frequency. An added confusion is that the value and unit used for g is inconsistent across centres and specifications (10, 9.8 or 9.81 m/s^2 or N/kg).
Use of Graphs	Students will have plotted scatter graphs before and be familiar with drawing lines of best fit.	Finding gradients will be challenging for weaker students. The concept of the gradient revealing the value of a physical constant will be new.

Teaching ideas

Objectives

- Explain the difference between weight and mass and use units to identify them.
- Use and re-arrange the equation $W = mg$.
- Use graphs to find gravitational field strength.

Starter activities

What is wrong?

This activity challenges the misconceptions surrounding weight and mass and highlights the lack of overlap between everyday language and physics.

Identify the mistake in these statements.

- I've put on weight.
- The object's big mass made it hard to lift.
- I weighed myself today and found I was 80 kg.
- The extra mass of the ballast made the ship sink.

What do you know?

This activity encourages students to extract information from text. It also asks students to interconvert mass and weight.

Extract as much information as you can from these passages a) by reading them and b) by using what you have read to work things out.

The 90 kg rugby player sprinted 50 m in 6 s.

The aeroplane remained at constant height due to an upward pressure of 20 000 N. It covered 450 km in its 2-hour flight.

The fully laden ship displaced 5000 kg of water, whilst when empty it only displaced 300 kg.

A 3 cm long grasshopper can jump 20 times its own body length.
The jump takes 0.35s.