Collins

GCSE science ready

Intervention tasks

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INTRODUCING *GCSE SCIENCE READY*

What is *GCSE science ready*?

GCSE science ready provides teachers with the tools to help them judge how far students have mastered the key ideas and skills at Key Stage 3, and then to respond in an innovative and effective way to ensure they have achieved mastery before GCSE.

It is a teaching tool of two parts.

- The first part consists of 40 transition tests which assess the entire AQA KS3 Science Syllabus, split into 'before' and 'after' tests, which cover the same syllabus content, but in slightly different ways to discourage rote learning. The 'before' tests diagnose gaps and weaknesses and the 'after' tests provide a second round of testing to ensure learning is embedded.
- The second part consists of 20 intervention tasks which provide a ready-made and targeted teaching response to gaps or weaknesses diagnosed by the tests. The intervention tasks mirror the topics covered by the tests to provide specific intervention solutions for areas highlighted by the testing.

At its heart this is a process that can be referred to as **Assess – Teach – Assess** and provides accurate progress monitoring as well as longevity of learning. In order to make teaching more effective, we need to have a clear idea about what has been mastered and what is still developing. In order to then have a positive impact upon student progress and outcomes, we need to be able to intervene and revisit ideas. Reassessing then allows us to gauge how far pupils have come.

We have worked hard to ensure this resource is highly relevant for teachers, saving time and supporting successful outcomes. To this end we have made sure that:

- The content is fully matched to the content, principles and organisation of the AQA Syllabus; its 10 big ideas and 16 enquiry processes.
- The content is aligned with the GCSE 9–1 assessment objectives, required mathematical knowledge and working scientifically skills to ensure it supports GCSE mastery.
- Tests and interventions provide clear diagnoses of problem areas and support for struggling students, as well as indicating areas for progression and extension activities for exceptional students.
- All resources are provided in Word on CD-ROM allowing teachers to edit and print as required.

How should it be used?

The books are designed to be used flexibly according to need; it is not a publication that has to be used in one specific way in order to work effectively.

There are a number of ways in which these materials can be used.

1. **Bespoke to AQA but relevant to all specifications**: This tool is bespoke to the AQA KS3 Science Syllabus and is ideal for those who are using this structure in their teaching. However, this tool could equally be used with an existing scheme of work as it comprehensively covers all the key concepts and skills in the National Curriculum and it clearly outlines the topics each test and intervention cover.
2. **Use in class, at school or at home**: Time is precious at Key Stage 3 and each teacher will have a different approach to assessment and intervention activities and where they can be best integrated. The tests can be set in class, during personal study time or for homework. Intervention tasks can be set as active class activities, group discussion points or amended as homework questions.
3. **Use in a formative or summative way at KS3 or GCSE**: The materials are designed to be used flexibly in response to how KS3 and GCSE is taught and how the class is progressing. Whether used consistently after each KS3 unit to ensure learning is embedded; in response to a particularly challenging topic; at the end of each year of KS3 to feed into revision; or just before GCSE to ensure students are 'GCSE ready', it will provide detailed guidance on what pupils have 'got' and what they are struggling with. The intervention tasks will provide a ready-made solution.

A note on the transition tests

The transition tests dovetail with the intervention tasks and are designed to be used in conjunction with them according to the **Assess – Teach – Assess** model. These are available in a separate volume. Although the transition tests provide an easy to use and bespoke solution to assessment, we acknowledge there are a range of different approaches to diagnosing what the next steps in learning are.

Key features of the transition tests:

- Comprehensive coverage of AQA's big ideas and enquiry processes so the entire syllabus is evaluated without the need to track every statement in the KS3 Programme of Study.
- Each test consists of 25 marks and each takes 20–30 mins to complete.
- Items are grouped into 10 'know' marks, 10 'apply' marks and five 'extend' marks, allowing clear diagnoses of the AQA mastery statements as well as optional extend knowledge.
- This breakdown of questions reflects the GCSE assessment objectives of 40% knowledge and understanding, 40% application and 20% interpretation and evaluation.
- A simple tracking chart will allow test marking to be recorded by difficulty of question and pupil progress to be understood in detail to aid diagnosis and intervention.

How does this tool relate to Collins AQA KS3 Science course and Collins AQA GCSE Science course?

This tool is designed to be used alongside the Collins AQA KS3 course and the Collins AQA GCSE (9–1) course to provide a complete set of resources to support the 'five year journey' from year 7 to 11, ensuring that the progression between KS3 and GCSE is seamless.

Bespoke to the AQA KS3 Syllabus and serving the priorities and assessment objectives of the AQA (9–1) GCSE this tool complements and support these courses.

THE AQA KEY STAGE 3 SYLLABUS

This teaching tool is relevant for all schools as it covers the Programme of Study for Key Stage 3 Science comprehensively, but it is designed to be bespoke to the AQA KS3 Science Syllabus.

The AQA KS3 Syllabus breaks down the scientific concepts into 10 big ideas across physics, chemistry and biology. Each of these are then sub-divided into four smaller topics. There is a suggested running order of these topics that reflects a progression in complexity. For example, AQA breaks the four topics in each big idea into pairs to be taught in year one and year two. They often sit together well but the association is stronger in some pairs than others. This structure is a suggestion and there is a degree of flexibility for teachers who wish to adapt this approach. However, what is important is to be able to revisit each of the ideas periodically to embed learning, a key tenet of AQA's 'spiral design for understanding'.

AQA's 10 big ideas	Part 1		Part 2	
1. Forces	Speed	Gravity	Contact forces	Pressure
2. Electromagnets	Voltage and resistance	Current	Electromagnets	Magnetism
3. Energy	Energy costs	Energy transfer	Work	Heating and cooling
4. Waves	Sound	Light	Wave effects	Wave properties
5. Matter	Particle model	Separating mixtures	Periodic table	Elements
6. Reactions	Metals and non-metals	Acids and alkalis	Chemical energy	Types of reaction
7. Earth	Earth structure	Universe	Climate	Earth resources
8. Organisms	Movement	Cells	Breathing	Digestion
9. Ecosystems	Interdependence	Plant reproduction	Respiration	Photosynthesis
10. Genes	Variation	Human reproduction	Evolution	Inheritance

Within each topic the ideas are grouped into 'Know', 'Apply' and 'Extend'. 'Know' and 'Apply' are equated to mastery and are summarised in 'mastery statements'. These statements clearly outline the key ideas, including key words, and how students should be able to apply them. Although the 'Extend' material is not essential for mastery, it offers a potential next step for students who have the ability to progress further.

Working scientifically is dealt with in a slightly different way. There are four main skill areas, each of which is broken down into four smaller areas or enquiry processes, 16 in all. Knowledge is dealt with in terms of both skills and skill integration, followed by the application of those skills.

AQA's 16 enquiry processes

Analyse

1. Analyse patterns
2. Discuss limitations
3. Draw conclusions
4. Present data

Communicate

1. Communicate ideas
2. Construct explanations
3. Critique claims
4. Justify opinions

Enquire

1. Collect data
2. Devise questions
3. Plan variables
4. Test hypotheses

Solve

1. Estimate risks
2. Examine consequences
3. Review theories
4. Interrogate sources

Although concepts (big ideas) and processes (enquiry processes) are dealt with separately, it is not intended that they should be delivered in this way. Each topic has a suggested investigation which shows how teaching can address and integrate both concepts and processes.

GCSE-readiness and the importance of mastery

The idea of mastery is a powerful one. We want students to master ideas and processes because we know that science is hierarchical and that to progress to higher levels, firm foundations need to be built. It is attractive to be able to say that something has been mastered (or not) because it enables us to manage and structure learning. But we know from our own experience that things, once learned, don't necessarily stay learned. Things we once understood, we may then find some time later are not so clear or crisp. How can we use the idea of mastery to secure progress?

This has direct relevance when looking at the role of Key Stage 3. The GCSE 9–1 specifications accredited and introduced in 2016 were designed to be rigorous and challenging. In order for students to make good progress from 11 to 16, KS3 has to be functional in building firm foundations. It needs to equip students with a 'working capital' of knowledge and understanding to enable them to approach KS4 courses with confidence, curiosity and a good chance of success and GCSE-readiness.

There are five aspects that are important to helping to make this a practical reality and the AQA KS3 Syllabus includes these.

The first thing is to be clear about which ideas and skills are the 'deal breakers'. It's no good saying 'it's all important' – it is, but we know that few students will grasp everything. A more useful approach is to identify which aspects can be equated to mastery, and focus effort on getting as many students as possible to that stage. Rather than spending time assessing what proportion of material each student has mastered, we can develop creative approaches to ensure that most students are at the 'GCSE ready' point. The 'Know' and 'Apply' sections of the AQA KS3 Syllabus are really clear about this.

The second thing is to analyse performance efficiently, to find out which ideas and skills have been mastered and to allow time to respond. Assessment is a cornerstone of this approach to inform next steps in teaching and learning.

The third aspect is being able to intervene if it becomes clear that some skills and ideas are not yet secure. The secret of good teaching is to find ways of coming at a concept from a different angle. Students value and appreciate teachers being able to explain ideas in different ways. It shouldn't be imagined that intervention means re-teaching using the same activities again. It is a cue for more creativity in the classroom, not less.

The fourth aspect is being able to apply and extend the use of ideas. Ideas in themselves are of little value; it is when they are used as tools to develop explanations, suggest applications or prompt further enquiry questions that they become powerful. Some facts may (or may not) have a passing interest but it is when the ideas are used to make sense of things or to devise approaches or solutions that deeper learning occurs.

The fifth aspect is being able to re-visit ideas. No matter how well learned in the first place, students may find it difficult to recall ideas if they have been unused for an extended period of time. If the teacher has a clear view of the underlying big ideas and engineers the curriculum so that they are revisited periodically, then students stand a better chance of retaining a grasp of them.

KEY FEATURES OF EACH INTERVENTION TASK

- There are 20 intervention tasks, each of which looks at two topics within a big idea. Thus for Earth, for instance, there is an Earth 1 intervention task looking at Earth structure and Universe and an Earth 2 intervention task looking at Climate and Earth resources. However, teachers are welcome to use the tasks in whichever order suits their teaching approach.
- We are not proposing lessons with markedly different plans for individual pupils with different attainment profiles after testing. It might be tempting to develop one kind of intervention for students who got lower marks on the 'know' section, another for those who didn't perform well on the 'apply' section and so on. In this case you may want to suggest a different emphasis, but it's not realistic to run entirely separate lessons in parallel.

Each task has the same set of features: this is an explanation of what they are and their intended function.

Learning context

The purpose of this section is to put the task into a context within the AQA KS3 Syllabus. It makes it clear which of the 10 big ideas, which of the topics within those ideas and which enquiry processes are being addressed.

The topics are approached in pairs and each pair comes from either the first half (year one) or the second half (year two) of the syllabus.

Each task addresses a particular aspect of scientific enquiry; these have been selected both to sit well with the context, but also to ensure that between the tasks all of the processes have been covered.

- **Focus**
  The focus of the task is a very brief descriptor, enabling a teacher to see at a glance what is involved.
- **Diagram**
  The diagram shows the relationship of this strand to other strands within the same key stage and also to material in the preceding and following key stages.
  The purpose of this is to enable the teacher to see: whether students may have met some of these ideas before starting in secondary school; how the ideas are then used in GCSE courses and also to show other topics in Key Stage 3 with which there is a significant relationship.
- **Key words**
  The AQA KS3 Syllabus places significant emphasis upon students knowing key terms. This list identifies the terms for these strands. It is not necessarily advocated that students are presented with these en masse; they are provided here for reference purposes.

TEACHING TASK

The teaching task is described both in terms of form and function so that it can either be used 'as is', or modified according to the situation it is to be used in. Our aim is to provide rich, varied, open-ended tasks and discussion points that provide more interesting and varied engagement with students.

The idea

This gives a clear indication of the particular concept, or concepts, being addressed in the task.

Eliciting students' ideas

This indicates how students can be drawn into the task and engaged with the context. It may well consist of some form of stimulus activity to attract students' attention and suggest a line of questioning to use. The purpose is not to elicit specific answers, but to indicate an area of thought.

The task

This then suggests a particular activity to do with students. It may take a variety of forms and is designed to develop the ideas further, usually with an image, demonstration or practical activity.

Equipment required

This indicates any resources that will be needed.

Questions and activities

This suggests particular areas of questioning to use as part of the activity. It is important to remember that the focus isn't so much students doing the activity, or the teacher explaining something, but rather questions being used to develop ideas and prompt responses that indicate understanding. Although a number of questions are offered and these fit a certain format, they should be regarded less as a set script to be followed and more as an indication of the appropriate type of questions.

The questions could be used in various ways. They could be used orally, with the teacher questioning students as a whole class or, for example, table groups. They could be displayed as a guide to students' thoughts and discussions or they could be printed and circulated. They are not designed to be answered in writing in silence, but could be used this way for homework or personal study.

The prime purpose is to establish what students think, what terms they use, what ideas they have grasped and how they can apply them. In order to use them effectively, teachers need to deploy skills and to respond to students' ideas.

The questions are grouped into the key categories of know, apply and extend; their nature therefore moves from relatively closed questions based on the use of key terms through to more open questions, often inviting some speculation and requiring students to use several ideas to construct a full response.

INTERPRETING STUDENT RESPONSES AND PROBING UNDERSTANDING

The crucial feature of using these materials is not 'did the students answer all the questions?' but rather 'what did I, their teacher, learn from their responses?' This section starts with a reference to misconceptions. Although misconceptions are many and varied, research has shown that there are quite a number that are commonplace; it is wise for a teacher to be aware of these, be alert to their possible existence and to know how to respond.

The references to misconceptions here are related to the impressive and extensive meta study carried out by the American Association for the Advancement of Science. The study references research from a range of sources and indicates the extent to which it is likely that such an idea may persist.

What follows is an indication, under the headings of know, apply and extend, of the areas a teacher can usefully consider. Finding out the extent to which students can do those things is useful, for several reasons:

- it often helps students to clarify their own ideas
- it indicates to the teacher where ideas can be introduced or revisited
- it supports students in supporting each other – one idea being articulated may well prompt a different or better idea from other members of the group.

This aspect is concerned not only with finding out what students' level of understanding is, but also in responding to it. In so doing, a teacher may wish to use other questions, examples or explanations.

We have included a nuanced commentary for teachers, particularly non-specialists, to help them assess mastery in students' engagement with tasks.

FURTHER IDEAS FOR INTERVENTION TASKS

It may become clear during the course of the lesson that more activities are needed to support further focused teaching. It may have become apparent that some students would benefit from further support and that the teacher may find it useful to use other contexts to encourage exploration and application of ideas. We have taken the approach that revisiting ideas or skills is often better done in a different way from the one originally used. After all, if some students didn't make much progress the first time, it might make sense to try a different tack in the intervention.

Once again, these are not intended as an exclusive list or the only conceivable ways of approaching these ideas; it is likely that good teachers will have their own approaches, or develop them, to achieve the same ends.

APPENDIX: AQA SYLLABUS STATEMENTS

Rather than try to assess all of these, the authors have been selective and picked out certain statements. This is partly because of practicalities – assessing everything would reduce time for teaching – but also because there is a strong linkage between the ideas in a topic. If students are responding well to the lines of reasoning suggested here, a teacher can be reasonably confident they are progressing well across the topic. These tables indicate the particular ideas and skills addressed.

However, the transition tests provide a broader assessment; it may be that the results of these indicate particular areas of poor understanding that need to be addressed.

AQA SYLLABUS REFERENCES BY INTERVENTION TASK

Intervention	AQA Big idea	AQA Topics	AQA Enquiry processes	Focus
1. Forces 1	3.1 Forces	3.1.1 Speed 3.1.2 Gravity	2.4 Present data 2.9 Collect data	Describing the motion of falling objects
2. Electromagnets 1	3.2 Electromagnets	3.2.1 Voltage and resistance 3.2.2 Current	2.10 Devise questions 2.11 Plan variables	Modelling voltage and resistance
3. Energy 1	3.3 Energy	3.3.1 Energy costs 3.3.2 Energy transfer	2.3 Draw conclusions 2.5 Communicate ideas	Energy resources and transfers between energy stores
4. Waves 1	3.4 Waves	3.4.1 Sound 3.4.2 Light	2.2 Discuss limitations 2.9 Collect data	Comparisons between wave types
5. Matter 1	3.5 Matter	3.5.1 Particle model 3.5.2 Separating mixtures	2.8 Justify opinions 2.12 Test hypotheses	Energy changes in changes in state
6. Reaction 1	3.6 Reactions	3.6.1 Metals and non-metals 3.6.2 Acids and alkalis	2.1 Analyse patterns 2.9 Collect data	Reactivity of metals in acid
7. Earth 1	3.7 Earth	3.7.1 Earth structure 3.7.2 Universe	2.3 Draw conclusions 2.7 Critique claims	Studying rocks to discover more about the planet Mars
8. Organisms 1	3.8 Organisms	3.8.1 Movement 3.8.2 Cells	2.5 Communicate ideas 2.6 Construct explanations	Looking at cells to identify both generic characteristics and also specialised features and looking at skeletons to apply ideas about their form and function
9. Ecosystems 1	3.9 Ecosystems	3.9.1 Interdependence 3.9.2 Plant reproduction	2.8 Justify opinions 2.16 Interrogate sources	Understanding the importance of pollinators
10. Genes 1	3.10 Genes	3.10.1 Variation 3.10.2 Human reproduction	2.5 Communicate ideas 2.14 Examine consequences	Human reproduction and inheritance of characteristics
11. Forces 2	3.1 Forces	3.1.3 Contact forces 3.1.4 Pressure	2.10 Devise questions 2.11 Plan variables	Forces in equilibrium
12. Electromagnets 2	3.2 Electromagnets	3.2.3 Electromagnets 3.2.4 Magnetism	2.3 Draw conclusions 2.15 Review theories	How forces can be applied without contact and how fields can be used to represent these effects
13. Energy 2	3.3 Energy	3.3.3 Work 3.3.4 Heating and cooling	2.5 Communicate ideas 2.6 Construct explanations	Energy transfer in simple machines
14. Waves 2	3.4 Waves	3.4.3 Wave effects 3.4.4 Wave properties	2.5 Communicate ideas 2.6 Construct explanations	A comparison of light and sound
15. Matter 2	3.5 Matter	3.5.3 Periodic table 3.1.4 Elements	2.2 Discuss limitations 2.13 Estimate risks	Making salts from Group 1 and Group 7
16. Reactions 2	3.6 Reactions	3.6.3 Chemical energy 3.6.4 Types of reaction	2.1 Analyse patterns 2.4 Present data	Exothermic reactions
17. Earth 2	3.7 Earth	3.7.3 Climate 3.7.4 Earth resources	2.8 Justify opinions 2.13 Estimate risks	Extraction of aluminium and effects of waste products
18. Organisms 2	3.8 Organisms	3.8.3 Breathing 3.8.4 Digestion	2.6 Construct explanations 2.7 Critique claims	Digestive and gas exchange systems
19. Ecosystems 2	3.9 Ecosystems	3.9.3 Respiration 3.9.4 Photosynthesis	2.12 Test hypotheses 2.14 Examine consequences	Cycling of carbon
20. Genes 2	3.10 Genes	3.10.3 Evolution 3.10.4 Inheritance	2.15 Review theories 2.16 Interrogate sources	Examining evolution of the elephant

1. Forces 1

LEARNING CONTEXT

AQA Big idea: 3.1 Forces

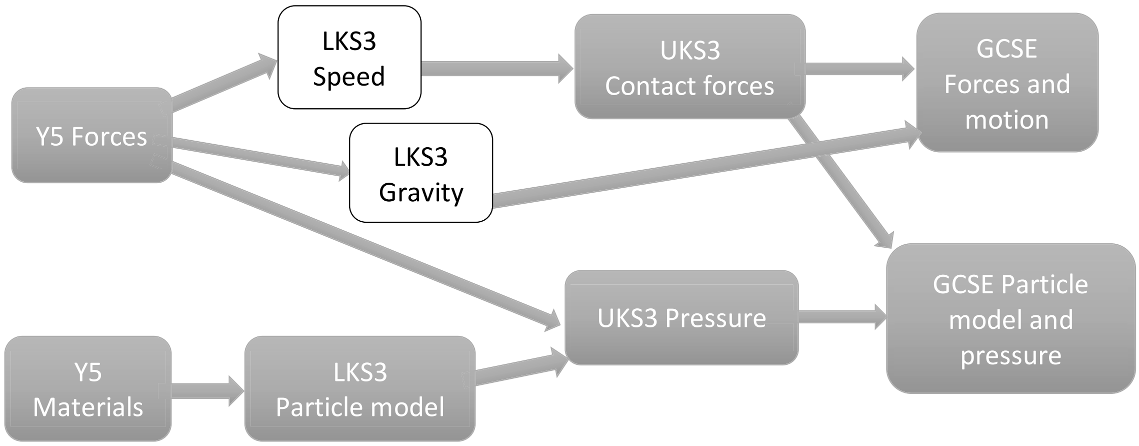
AQA Strands: 3.1.1 Speed 3.1.2 Gravity

AQA Enquiry processes: 2.4 Present data 2.9 Collect data

Focus of this task: Describing the motion of falling objects

How this provides GCSE readiness: Calculating the speed of an object using the distance travelled and time taken is an important skill in GCSE specifications and a key idea that underpins knowledge of acceleration, velocity and braking and stopping distances. Gravity as a force that causes acceleration is also linked to the speed at which objects travel and their terminal velocity.

Diagram showing the relationship of teaching topics



Key words

- Speed
- Average speed
- Relative motion
- Acceleration
- Weight
- Non-contact force
- Mass
- Gravitational field strength
- Field
- Range
- Interval
- Control group
- Repeatable
- Bar chart/column graph
- Line graph
- Pie chart
- Line of best fit
- Scatter graph

TEACHING TASK

The idea

Gravity is an attractive force between two masses that causes them to come together. For example, the gigantic mass of the Earth pulls us puny humans towards it. This is most noticeable when humans hurl themselves from planes. They accelerate rapidly towards the earth until reaching their terminal velocity; the constant speed that results from the force of gravity being equalled by the force of resistance of the medium they are falling through, in this case, air. The resistance of the air prevents the body from getting any faster, there is 0 acceleration and the speed is constant. Rapid deceleration can then be caused by the simple act of opening a parachute and increasing the resistance.

Eliciting students' ideas

Ask: If gravity is a force that causes objects to accelerate towards the ground at the same speed (9.81m/s), why do objects fall at different speeds? Use a piece of paper and a small pen and ask the students which weighs more and which they would expect to hit the floor first. Then take two more sheets of paper and crumple one of them into a ball. Ask if the mass of the two pieces of paper is the same and, again, which will hit the floor first? Students should come to the idea that air resistance affects how fast the objects fall. Ask students to consider if they have the same air resistance, will the objects fall at the same rate?

The task

Provide the students with 10 cupcake cases each. Show them how, by placing one inside the other, they can change the weight but keep the shape of the object and, therefore, the air resistance it will experience, the same.

Ask students to design an experiment to find out if the mass of the cupcake cases affects the speed at which they fall. They should devise their own hypothesis, for example, the greater the mass, the less time it will take for cupcake case to fall.

Equipment required

- 10 cupcake cases per group
- a location where cupcakes can be dropped from a height (for example, a stairwell, from the stage, out of a safe window, or even just from arm's length – so long as over a metre)
- a stopwatch
- slow motion capable smartphones or cameras (if possible)
- graph paper
- rulers

QUESTIONS AND ACTIVITIES

KNOW

- Represent those forces indicating name and direction and compare their size.
- Use the formula: speed = distance (m)/time (s) to calculate the speed of your falling cupcake cases.
- What does acceleration mean?
- What is the name of the force that works against gravity?
- What would happen to the acceleration of the cupcake case as this force gets bigger?

APPLY

- What forces are acting on the cupcake case as it reaches its terminal velocity?
- Represent those forces on a diagram indicating name and direction and compare their size.
- As an observer of your falling cupcake case, describe how the speed varies during the drop.
- Imagine you are a cupcake case that is dropped at the same time as another. Describe what you would observe as you fall with your fellow cupcake case; what would the other cupcake case's speed look like relative to you?
- What happens to the force of air resistance as the cupcake case speeds up?
- What happens when the force of air resistance and the force of gravity are the same?

EXTEND

- Explain, in terms of forces, why the cupcake case starts to accelerate when you let go of it.
- Explain, in terms of forces, why the cupcake case does not accelerate when you are holding on to it.
- How are the forces of gravity and air resistance different?
- What force would you say gravity is most similar to and why?
- Why is there no apparent gravity in space?
- How can you prove that the force of gravity is still there, but is just weaker?
- How do gravity and air resistance help and hinder space programs?

INTERPRETING STUDENT RESPONSES AND PROBING UNDERSTANDING

Where previous questions have helped to explore students' knowledge, these bullet points outline only what is required for mastery of the topic and extension of that knowledge, so it is easy to assess progress throughout the activity.

Research shows that some students hold misconceptions in this area, including:

- Thinking that an impelling force can become part of an object.
- Thinking in the case of two opposing forces that the greater force wins, with it then becoming the total acting force.
- If an object is slowing down, a force that was moving it forward must be decreasing.
- If an object's speed is decreasing, a force that is retarding the object's motion must be increasing.
- A moving object has a force within it that keeps it moving.

References to these can be found in the AAAS meta study on misconceptions in science.

KNOW

- Can the student identify the various forces that are acting on the cupcake case at different stages of the experiment?
- Can they recognise that gravity is a constant force?
- Can they display the data they have gathered?
- Can they calculate speed using a formula and their results?

  For example, for falling cupcake cases, students should be able to recognise that:

- Gravity is a constant force that causes acceleration towards the Earth.
- Cupcake cases will experience more air resistance the faster they go.
- Speed can be calculated using the formula speed = distance (m)/time (s).

A key idea is that a zero resultant force causes zero acceleration, this will occur when the object is stationary AND when the object is at terminal velocity. It is worthwhile probing this a little to avoid students thinking that all moving objects (even those travelling at constant velocity) have non-zero resultant forces acting on them.

APPLY

- Can the student identify the direction and size of each of the forces?
- Can they suggest the overall size and direction of the resultant force?
- Can they recognise that observers travelling at the same speed as an object will observe the object as not moving?
- Can they suggest ways of improving their experiment?
- How could they improve the way they displayed the data?

  For example, for falling cupcake cases, students should be able to recognise that:

- These forces can be represented by arrows of different sizes and with zero resultant force, the forces are equal and opposite.
- An observer at the same speed as a moving object will observe the object as stationary whilst the world around them moves. This can also be observed on two moving trains next to each other.
- Experiment can be improved by more precise timing of the drop. Use of a slow motion camera would help identify when the case has hit the floor.

EXTEND

- Can the student equate a non-zero resultant force with acceleration?
- Can they equate a zero resultant force with constant speed or the object being stationary?
- Can they suggest forces that act in a similar way to gravity?
- Can they describe how air resistance is different to gravity?

For example, for falling cupcake cases, students should be able to recognise that:

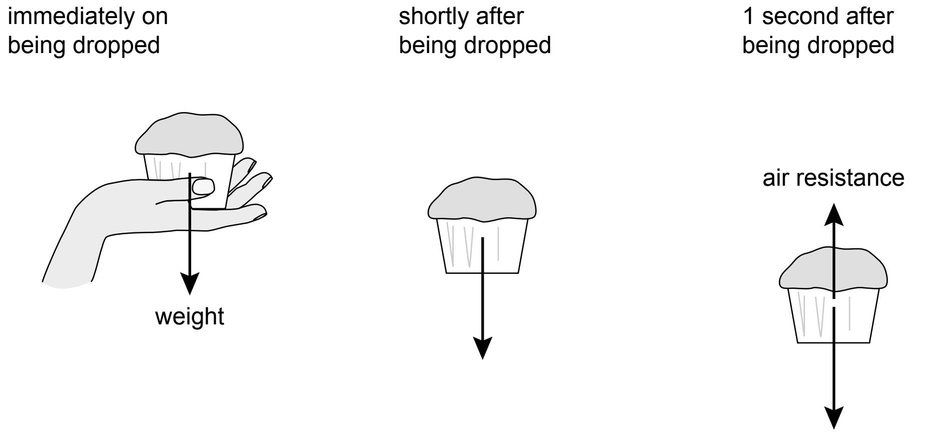
- When the cupcake is accelerating, the force of gravity is larger than the force of air resistance. As the cupcake case reaches terminal velocity, gravity remains the same, but air resistance increases. At terminal velocity, the two forces are equal and the resultant force is zero. Before the cupcake case is dropped, the reaction force from the hand is equal to the force of gravity – a zero speed, zero resultant force.
- A similar force could be magnetic force, as it acts at a distance and is attractive, like gravity.
- Air resistance is dissimilar because it is a contact force that slows down the object and works in the opposite direction to travel, much like friction.

FURTHER IDEAS FOR INTERVENTION TASKS

It is important to recognise ideas that have been mastered and to consider the next steps in learning. The area of mastery (e.g. apply) provides a useful stem for giving feedback to students.

Depending on the profile of progress, it might be appropriate to organise some further intervention. Examples of this might include:

- Provide the students with a diagram of one cupcake case being held before it is dropped. Draw force diagrams of the entire journey of the cupcake case.



- Discuss the motion of an air-powered bottle rocket that is fired into the air and compare the forces in action. When the rocket is fired, air resistance will work in the same direction as gravity. When the rocket reaches the highest point of its launch and begins to fall, air resistance will then work in the opposite direction. Students can discuss the combined effect of gravity and air resistance for the launch, especially the magnitude of air resistance, which will be highest soon after launch and then decrease.
- Discuss the effects of gravity at a distance and consider the orbits of the planet. If a planet suddenly halted in its sideways trajectory as it orbited the Sun, what would happen next? If, suddenly, all motion in the universe was halted, what would happen next? Why are planets able to maintain orbits for such a long time? What would happen if they slowed down/sped up?

APPENDIX: AQA syllabus statements covered in this task

a) Speed of an object

Area of mastery	Objectives relating to the speed of an object
Know	If the overall, resultant force on an object is non-zero, its motion changes and it slows down, speeds up or changes direction.
Apply	Describe how the speed of an object varies when measured by observers who are not moving, or moving relative to the object.
Extend	Predict changes in an object's speed when the forces on it change.

b) Gravity

Area of mastery	Objectives relating to gravity acting on an object
Know	Every object exerts a gravitational force on every other object. The force increases with mass and decreases with distance. Gravity holds planets and moons in orbit around larger bodies.
Apply	Draw a force diagram for a problem involving gravity.
Extend	Compare and contrast gravity with other forces.

c) Working scientifically

Area of mastery	Present data
Know: individual skills	Decide the type of chart or graph to draw based on its purpose or type of data. Design a table for the data being gathered. Label the *x* axis with the name of the independent variable and the *y* axis with the dependent variable. Write unit labels on the axes. Decide which numbers to start and finish with on each axis. Mark out an equal scale showing what each square of graph paper represents. Draw a straight line or a curve of best fit through the points.
Know: integration	Select a good way to display data. Draw line graphs to display relationships.
Apply: understand principles	Explain why different kinds of data are better displayed on different kinds of graphs. Explain the choice of starting point for axes, zero or non-zero. Explain the choice of a straight line or curve of best fit. Explain the choice of type of graph.

Area of mastery	Collect data
Know: individual skills	Choose a suitable range for the independent and dependent variable. Gather sufficient data for the investigation and repeat if appropriate. Prepare a table with space to record all measurements. Check that the measuring instrument can measure the complete range of the independent variable. Check you can detect differences in the dependent variable. Use the measuring instrument correctly. Carry out the method carefully and consistently. See if repeated measurements are close. Remove outliers and calculate mean of repeats.
Know: integration	Choose range and interval of readings. Test suitability of measuring instrument. Gather data, minimising errors.
Apply: understand principles	Explain why having a large range or many readings leads to accurate data. Describe the factors that influence the choice of range and interval for the variables.