Activate for AQA and AQA GCSE Physics Scheme of Work - Forces

This sample Five Year Scheme of Work is suitable for teaching *Forces* for AQA Key Stage 3 Science and AQA GCSE Physics.

On the following page is a visual summary of the five years of KS3 and GCSE Science that shows where the AQA GCSE Science series follows on from the topics covered at Key Stage 3 in Activate for AQA. Following are the schemes of work for KS3 and GCSE on Forces.

Use the navigation pane to find the topic you are looking for.
<table>
<thead>
<tr>
<th>KS3 Part 1</th>
<th>KS3 Part 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forces</strong></td>
<td><strong>1.1 Speed</strong></td>
</tr>
<tr>
<td>Electro-magnets</td>
<td>2.1 Potential difference and resistance</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>3.1 Energy costs</td>
</tr>
<tr>
<td><strong>Waves</strong></td>
<td>4.1 Sound</td>
</tr>
<tr>
<td><strong>Matter</strong></td>
<td>5.1 Particle model</td>
</tr>
<tr>
<td><strong>Reactions</strong></td>
<td>6.1 Acids and alkalis</td>
</tr>
<tr>
<td><strong>Earth</strong></td>
<td>7.1 Earth Structure</td>
</tr>
<tr>
<td><strong>Organisms</strong></td>
<td>8.1 Movement</td>
</tr>
<tr>
<td><strong>Ecosystem</strong></td>
<td>9.1 Inter-dependence</td>
</tr>
<tr>
<td><strong>Genes</strong></td>
<td>10.1 Variation</td>
</tr>
</tbody>
</table>

**Paper 1**

- **1 Cells and organisation**
  - B1 Cell structure and transport
  - B2 Cell division
  - B3 Organisation and the digestive system
  - B4 Organising animals and plants
- **2 Disease and bioenergetics**
  - B5 Communicable diseases
  - B6 Preventing and treating disease
  - B7 Non-communicable diseases
  - B8 Photosynthesis
  - B9 Respiration

**Paper 2**

- **3 Biological responses**
  - B10 The human nervous system
  - B11 Hormonal coordination
  - B12 Homeostasis in action
- **4 Genetics and reproduction**
  - B13 Reproduction
  - B14 Variation and evolution
- **B5 Ecology**
  - B15 Genetics and evolution
  - B16 Adaptations, interdependence, and competition
  - B17 Organising and ecosystem
  - B18 Biodiversity and ecosystems

**Paper 1**

- **3 Rates, equilibrium and organic chemistry**
  - C1 Atomic structure
  - C2 The periodic table
  - C3 Structure and bonding
  - C4 Chemical calculations
- **2 Chemical reactions and energy changes**
  - C5 Chemical changes
  - C6 Electrolysis
  - C7 Energy changes
  - C8 Rates and equilibrium
  - C9 Crude oil and fuels
  - C10 Organic reaction
  - C11 Polymers

**Paper 2**

- **4 Analysis and the Earth’s resources**
  - C12 Chemical analysis
  - C13 The Earth’s atmosphere
  - C14 The Earth’s resources
  - C15 Using our resources

**Paper 1**

- **1 Energy and energy resources**
  - P1 Conservation and dissipation of energy
  - P2 Energy transfer by heating
  - P3 Energy resources
- **2 Particles at work**
  - P4 Electric circuits
  - P5 Electricity in the home
  - P6 Molecules and matter
  - P7 Radioactivity

**Paper 2**

- **3 Forces in action**
  - P8 Forces in balance
  - P9 Motion
  - P10 Force and motion
  - P11 Force and pressure
- **4 Waves, electromagnetism, and space**
  - P12 Wave properties
  - P13 Electromagnetic waves
  - P14 Light
  - P15 Electromagnetism
  - P16 Space

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)
This resource sheet may have been changed from the original.
# Activate for AQA 1

<table>
<thead>
<tr>
<th>Section</th>
<th>AQA syllabus statement</th>
<th>Outcomes</th>
<th>Lesson overview</th>
<th>Kerboodle Resources and Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Forces</td>
<td><strong>Securing Mastery Goals</strong>&lt;br&gt;● 3.1.2 Draw a force diagram for a problem involving gravity.&lt;br&gt;&lt;br&gt;<strong>Extending Mastery Goals</strong>&lt;br&gt;● 3.1.2 Compare and contrast gravity with other forces.&lt;br&gt;&lt;br&gt;<strong>Enquiry processes</strong>&lt;br&gt;● 2.9 Use the measuring instrument correctly.&lt;br&gt;● 2.12 Make an experimental prediction.</td>
<td><strong>Know</strong>&lt;br&gt;- Describe what forces do.&lt;br&gt;- Identify a 'contact force', 'non-contact force', and 'newton'.&lt;br&gt;- Use a newtonmeter to make predictions about sizes of forces.&lt;br&gt;&lt;br&gt;<strong>Apply</strong>&lt;br&gt;- Categorise everyday forces as 'contact' and 'non-contact' forces.&lt;br&gt;- Identify interaction</td>
<td>To start, students recap on what forces are and what they do, and individually name as many forces as possible. They then sort the forces into contact and non-contact forces. Give groups of students a pair of newtonmeters, linking the hooks together. Ask them to predict the readings on each newtonmeter if one student holds their newtonmeter and the other student pulls theirs away.&lt;br&gt;&lt;br&gt;In the main lesson activity, introduce newtons and newtonmeters. Students measure the force needed to carry out different activities and record these in a table. Introduce students to force diagrams and force arrows. Give students three arrows of different lengths to put on objects in a forces circus and describe them as 'the</td>
<td><strong>Practical</strong>: Measuring forces&lt;br&gt;&lt;br&gt;<strong>Interactive</strong>: Comparing the size of forces</td>
</tr>
<tr>
<td>pairs in a simple situation.</td>
<td>force of the ... on the’</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Interpret force diagrams used to illustrate problems involving gravity.</td>
<td>Either interactively or on the board, students list situations involving forces and put these in order, ranked by size.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Describe what 'interaction pair' means.</td>
<td>If students have measured the same thing during the practical ask them to compare results. Students discuss the types of forces in the forces circus (contact or noncontact) and identify some interaction pairs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Make predictions about forces in familiar situations.</td>
<td>For homework, students measure forces at home using cardboard and rubber band device.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Extend**

- Identify interaction pairs in complex situations.
- Explain the link between non-contact forces, contact forces, and interaction pairs.
- Make predictions about pairs of forces acting in unfamiliar situations.
### 1.1.2 Balanced and unbalanced forces

#### Securing Mastery Goals
- 3.1.2 Draw a force diagram for a problem involving gravity.

#### Exceeding Mastery Goals
- 3.1.2 Predict changes in an object’s speed when the forces on it change.

#### Enquiry processes
- 2.9 Gather sufficient data for the investigation and repeat if appropriate.
- 2.4 Select a good way to display data.

#### Know
- Identify familiar situations of balanced and unbalanced forces.
- Recognise equilibrium.
- Identify a resultant force.
- Identify when the speed or direction of motion of an object changes.
- Present observations in a table with help.

#### Apply
- Draw a force diagram for a problem involving gravity.
- Describe the difference between balanced and unbalanced forces.
- Describe situations that are in

To start, show a short video of a sports activity. Students list what happens as the motion of a person or object changes. Students describe their motion on a short car/bus journey.

In the main lesson activity, students identify forces acting on experiments in a circus and decide if they are balanced.

As part of the practical sheet, students sketch the force diagram for each experiment and identify situations where the resultant force is zero, and when it is not zero.

Students describe and act out how to change motion when you ride a bicycle, linking the ideas to the forces.

Interactive resource where students sort statements describing the motion of a football being kicked into balanced or unbalanced forces.

For homework, students list different situations at home where forces are balanced or unbalanced.

#### Practical:
- Force circus

#### Skill sheet:
- Scientific apparatus

#### Interactive:
- Balanced and unbalanced forces
**Five year scheme of work**

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Calculate resultant forces.</td>
<td>- Explain why the speed or direction of motion of objects can change.</td>
<td>- Present observations in a table including force arrow drawings.</td>
<td><strong>Extend</strong></td>
<td>- Explain the difference between balanced and unbalanced forces.</td>
</tr>
<tr>
<td>- Explain the link between the resultant force and the motion of an object.</td>
<td>- Explain why the speed or direction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Five year scheme of work

### 1.1.3 Speed

**Securing Mastery Goals**
- 3.1.1 Use the formula: speed = \( \frac{\text{distance (m)}}{\text{time (s)}} \) or distance–time graphs, to calculate speed.
- 3.1.1 The higher the speed of an object, the shorter the time taken for a journey.
- 3.1.1 Describe how the speed of an object varies when measured by observers who are not moving, or moving relative to the object.

**Exceeding Mastery Goals**
- 3.1.1 Suggest how the speed of an object varies when measured by observers who are not moving, or moving relative to the object.

<table>
<thead>
<tr>
<th>Know</th>
<th>Apply</th>
</tr>
</thead>
</table>
| - State the equation for speed and use it to calculate speed, with support.  
- Recognise relative motion.  
- Use appropriate techniques and equipment to measure times and distances. | - Calculate speed using the speed equation.  
- Describe relative motion.  
- Choose equipment |

To start, students estimate speeds in different situations using tangible examples.

Students measure the time taken for a ball to fall from a height of one metre. Discuss where the ball travelled slowest and fastest and introduce the speed equation.

For the main lesson activity, students investigate the effects of a selected variable on the average speed of a toy car as it rolls down a ramp. Students will have to calculate the speed of the car, as they vary the independent variable. Students choose the correct words on the interactive resource to summarise relative motion.

Students discuss who had the quickest reaction time, factors that affect it, and benefits of quick reaction time.

For homework, produce a safety leaflet explaining when drivers should slow down and explain the physics behind

**Practical:** Rolling, rolling

**Skill sheet:** Recording results

**Interactive:** Talking about relative speed
motion of two objects moving at different speeds in the same direction would appear to the other.

**Enquiry processes**
- 2.12 Make an experimental prediction.
- 2.11 Identify how to control each control variable.
- 2.9 Gather sufficient data for the investigation and repeat if appropriate.
- 2.12 Decide whether the conclusion of the experiment agrees with your prediction.
- 2.13 Identify risks and hazards.
- 2.13 Identify control measures.

**Enquiry processes activity**
- 3.1.1 Investigate variables that affect the

to make appropriate measurements for time and distance to calculate speed.

**Extend**
- Use the speed equation to explain unfamiliar situations.
- Describe and explain how a moving object appears to a stationary observer and to a moving observer.
- Choose equipment to obtain data for speed calculations, justifying their choice based on accuracy and precision.

this.
## Five year scheme of work

<table>
<thead>
<tr>
<th>1.1.4</th>
<th><strong>Distance-time graphs</strong></th>
<th><strong>Securing Mastery Goals</strong></th>
<th><strong>Know</strong></th>
<th><strong>Activity:</strong> Using distance-time graphs</th>
</tr>
</thead>
</table>
|       |                           | ● 3.1.1 Use the formula: speed = distance (m) ÷ time (s) or distance–time graphs, to calculate speed. | - Describe simply what a distance–time graph shows.  
- Use a distance–time graph to describe a journey qualitatively.  
- Present data given on a distance–time graph, with support.  
- Calculate speed from a distance–time graph, with support. | For the main lesson activity, introduce the idea of distance–time graphs in interpreting movement in detail.  
Demonstrate how the slope of the graph shows speed.  
Students then interpret data on the activity sheet to plot a distance–time graph for a migrating bird, the Tour de France, or a sled dog race.  
Students match halves of sentences using the interactive resource to explain distance–time graphs.  
Each pair of students should draw a distance–time graph on a mini-whiteboard. Allow students to walk around the classroom to find other whiteboards, giving descriptions of graphs shown, or imagining the shape of a graph if the description is shown.  
For homework, students note down typical times and |

| **Enquiry processes** | [297x368] Describe simply what a distance–time graph shows.  
- Use a distance–time graph to describe a journey qualitatively.  
- Present data given on a distance–time graph, with support.  
- Calculate speed from a distance–time graph, with support.  
<p>| <strong>Interactive:</strong> What can you tell from a distance–time graph? |</p>
<table>
<thead>
<tr>
<th>units.</th>
<th>distances for a journey they make and produce a labelled distance–time graph.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Plot data on a distance–time graph accurately. Extend</td>
<td></td>
</tr>
<tr>
<td>- Draw distance–time graphs for a range of journeys.</td>
<td></td>
</tr>
<tr>
<td>- Analyse journeys using distance–time graphs.</td>
<td></td>
</tr>
<tr>
<td>- Manipulate data appropriately to present in a distance–time graph.</td>
<td></td>
</tr>
</tbody>
</table>
**1.2 Gravity**

**Securing Mastery Goals**
- 3.1.2 Use the formula: \( \text{weight (N)} = \text{mass (kg)} \times \text{gravitational field strength (N/kg)}. \)
- 3.1.2 \( g \) on Earth = 10 N/kg. On the moon it is 1.6 N/kg.
- 3.1.2 Explain unfamiliar observations where weight changes.
- 3.1.2 Deduce how gravity varies for different masses and distances.
- 3.1.2 Compare your weight on Earth with your weight on different planets using the formula.

**Exceeding Mastery Goals**
- 3.1.2 Draw conclusions from data about orbits, based on how gravity varies with mass and distance.
- 3.1.2 Suggest

**Know**
- Describe the difference between mass and weight.
- Describe simply how gravity varies with mass and distance.
- State the force that holds planets and moons in orbit around larger bodies.
- State \( g \) on the Earth and the moon.
- Use the formula \( \text{weight} = \text{mass} \times g \), with support.

**Apply**
- Describe how gravity due to an object changes if the mass or the distance from the object changes.
- Use a formula \( \text{weight} = \text{mass} \times g \) to work out your weight on different planets, and

To start, show students a video of astronauts on the Moon, and compare mass and weight. Students group forces given on the interactive resource into contact and non-contact forces.

For the main lesson activity, prepare sealed containers containing different masses of sand representing celestial bodies. Students weigh the containers, and use \( W = mg \). Students describe how their weight changes on a journey to the Moon. Demonstrate orbiting by rolling a football on the floor and provide a list of objects that orbit other objects. They draw diagrams to show the force of gravity on each one keeping it in orbit.

Students link list of five masses (and five equivalent weights) on the Earth and on the Moon. Ask students to compare an astronaut doing sport on the Earth and on the Moon.

For homework, write a holiday brochure for a trip to another planet, explaining conditions and how to prepare.

**Interactive:** Contact and non-contact forces

**Practical:** Gravity cups
<table>
<thead>
<tr>
<th>Enquiry processes</th>
<th>Enquiry processes activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>● 2.9 Prepare a table with space to record all measurements.</td>
<td>● 3.1.2 Explain the way in which an astronaut’s weight varies on a journey to the moon.</td>
</tr>
<tr>
<td>● 2.9 Gather data, minimising errors.</td>
<td></td>
</tr>
</tbody>
</table>

**Implications of how gravity varies for a space mission.**

- Prepare a table with space to record all measurements.
- Gather data, minimising errors.

**Enquiry processes**

**Activity**

- **Extend**
  - Compare and contrast gravity with other forces.
  - Explain how the effect of gravity changes moving away from Earth, and in keeping objects in orbit.
  - Analyse data about orbits in terms of the variation of gravity with mass and distance.
  - Present results in a table, ensuring they are reliable.

- Compare it to your weight on Earth.
  - Explain why your weight changes in unfamiliar circumstances.
### 1 Forces

<table>
<thead>
<tr>
<th>Section</th>
<th>AQA syllabus statement</th>
<th>Outcomes</th>
<th>Lesson overview</th>
<th>Kerboodle Resources and Assessment</th>
</tr>
</thead>
</table>
| 1.3.1   | **Securing Mastery Goals**
- 3.1.3 When the resultant force on an object is zero, it is in equilibrium and does not move, or remains at constant speed in a straight line.
- 3.1.3 Sketch the forces acting on an object, and label their size and direction.
- 3.1.3 Explain whether an object in an unfamiliar situation is in equilibrium.
- 3.1.3 Describe factors which affect the size of frictional and drag forces. | **Know**
- Identify examples of drag forces and friction.
- Describe how drag forces and friction arise.
- Write down two things an object can do when the resultant force on it is zero.
- Carry out an experiment to test a prediction of friction caused by different surfaces. | To start, students name and compare slippery/non-slippery surfaces, listing the features of the beast surfaces to slide on. **Support:** Show images of different surfaces. Group these as high/low friction. Students list three or four objects that move easily through water. The interactive resource can be used to identify features that change friction and drag. For the main lesson activity, students use newton meters to pull a box with masses in it along different surfaces. They record and analyse their results, drawing a graph of their results. Students drop 1 cm³ of plasticine in a column of water. They change its shape and compare how the shape affects the time taken to fall a fixed distance, and link this with forces involved. Students present data in a table. | **Interactive:** Friction and drag **Practical:** Investigating friction **Skill sheets:** Choosing scales, Planning investigations, Recording results, Drawing graphs |

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)
This resource sheet may have been changed from the original.
### Exceeding Mastery Goals
- 3.1.3 Evaluate how well sports or vehicle technology reduces frictional or drag forces.
- 3.1.3 Describe the effects of drag and other forces on falling or accelerating objects as they move.

### Enquiry processes
- 2.4 Draw a straight line or a curve of best fit through the points.
- 2.9 Gather data, minimising errors.
- 2.11 Plan method and identify how to control variables.
- 2.11 Decide how to vary the independent variable between planned values.

### Enquiry processes activity
- 3.1.3 Investigate factors that affect the size of frictional or drag forces.
- Describe the effect of drag forces and friction.
- Explain why drag forces and friction arise.
- Describe what happens to a moving object when the resultant force acting on it is zero.
- Plan and carry out an experiment to investigate friction, selecting suitable equipment.

### Extend
- Explain the effect of drag forces and friction in terms of forces.
- Explain why drag forces and friction slow things down in terms of forces.
- Interpret the motion of objects subject to drag forces and friction.
- Plan and carry out an experiment to investigate friction, selecting suitable equipment.

For plenary, interleave the pages of two magazines or phonebooks and ask students to pull them apart. Drop one cupcake case, then many cupcake cases. Students should explain the motion using ideas about gravity, air resistance, and resultant forces.

**Support**: Put up diagrams showing balanced and unbalanced forces, and list what happens to objects in either case.

For homework, students match features of different sport shoe soles with the surfaces and movement. They then write a short article about how the design of sportswear for athletes helps them move faster.
## Five year scheme of work

| 1.3.2 Squashing and stretching | **Securing Mastery Goals**
- 3.1.3 One effect of a force is to change an object’s form, causing it to be stretched or compressed. In some materials, the change is proportional to the force applied.
- 3.1.3 Describe how materials behave as they are stretched or squashed.
- 3.1.3 Describe what happens to the length of a spring when the force on it changes.
| **Know**
- State an example of a force deforming an object.
- Recognise a support force.
- Use Hooke’s Law to identify proportional stretching.
- State how you know from a graph that a relationship is linear, present data in a line graph, and identify a pattern.
| **Apply**
- Describe how forces deform objects.
- Explain how solid surfaces provide a support force.
- Use Hooke’s Law to predict the extension of a spring.
- Present data in a graph and identify a pattern. | To start, students explain what happens when a force is applied to particular objects and when the force is removed, introducing the idea of the reaction force. **Support:** Students describe what happens – you explain why in terms of forces. Place a heavy ball on the table, on a sponge, and in a beaker of water. Identify similarities and differences, and introduce the idea of the reaction force and how this is formed.

For the main lesson activity, students collect data for the change in length of springs and elastic. They record results in a table, plot a line graph, and describe the patterns. This is done as part of the questions on the practical sheet. Introduce Hooke’s Law and the definition of linear and non-linear relationships.

For plenary, students explain how to calculate the right length of rope to use for a bungee jump, and what happens if you get it wrong. **Support:** Students describe what happens to the rope in the video and why it helps to keep the jumper safe. Interactive resource that can be used as a recap for the experiment carried out in the lesson.
| **Question-led lesson:**
Squashing and stretching
**Practical:**
Investigating elastic
**Skill sheets:**
Choosing scales,
Calculating means,
Recording results
**Interactive:**
Stretching experiment |
<table>
<thead>
<tr>
<th>1.3.3 Turning forces</th>
<th><strong>Exceeding Mastery Goals</strong></th>
<th><strong>Know</strong></th>
<th><strong>Practical:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- 3.1.3 Explain how turning forces are used in levers.</td>
<td>- State the law of moments.</td>
<td>- State the equation to calculate a turning force.</td>
<td>Just a moment!</td>
</tr>
<tr>
<td><strong>Enquiry processes</strong></td>
<td>- Identify further questions from results with help.</td>
<td>- Identify questions from results with help.</td>
<td>Skill sheet: Recording results</td>
</tr>
<tr>
<td>- 2.3 Identify further questions arising from</td>
<td></td>
<td></td>
<td>Interactive:</td>
</tr>
</tbody>
</table>

| | quantitative relationship in the pattern. | For homework, students research one idea about the application of springs, including why the elastic behaviour is used, how it is controlled, how problems are avoided, and the energy changes that occur on deformation of the spring. |

**Extend**
- Explain how forces deform objects in a range of situations.
- Explain how solid surfaces provide a support force, using scientific terminology and bonding.
- Apply Hooke’s Law to make quantitative predictions with unfamiliar materials.
- Present data in a graph and recognise quantitative patterns and errors.

To start, set up a see-saw on the bench (using a plank and support). Students suggest how you can have two objects of unequal size and mass on either side of the see-saw.
Students compare pushing open a door with hands far away from the pivot, and hands close to the pivot. Introduce the concept of moments, and explain how a door acts as a force multiplier.
For the main lesson activity, illustrate moments using Hooke’s Law to make quantitative predictions with unfamiliar materials.

Present data in a graph and recognise quantitative patterns and errors.

For homework, students research one idea about the application of springs, including why the elastic behaviour is used, how it is controlled, how problems are avoided, and the energy changes that occur on deformation of the spring.
## Five year scheme of work

<table>
<thead>
<tr>
<th>investigations.</th>
<th><strong>Apply</strong></th>
<th><strong>Extend</strong></th>
<th><strong>Moments</strong></th>
</tr>
</thead>
</table>
|                 | - Describe what is meant by a moment.  
|                 | - Calculate the moment of a force.  
|                 | - Independently identify scientific questions from results. | - Apply the concept of moments to everyday situations.  
|                 | | - Use calculations to explain situations involving moments.  
|                 | | - Suggest relevant, testable questions.  
|                 | | |  
|                 |props around the classroom. Carry out simple moments calculations on the board to show the difference between clockwise and anticlockwise moments. Students then carry out a practical in which they investigate the turning force required to topple a clamp stand at different heights from the base, and answer questions that follow. |For plenary, pose the following question for students to solve: How can we pour drinks into two identical cups so that one cup has exactly twice the amount of the other without using scales or measuring the amount of liquid poured? **Support:** Prompt students towards what they have learnt this lesson.  
Students revise key terms used in this lesson using the interactive resource.  
For homework, students identify five examples that use the principle of moments at home, researching one in detail to explain how moments work in context. |

© Oxford University Press 2017 [www.oxfordschool.co.uk/acknowledgements](http://www.oxfordschool.co.uk/acknowledgements)  
This resource sheet may have been changed from the original.
<table>
<thead>
<tr>
<th>1.4.1</th>
<th><strong>Pressure in gases</strong></th>
</tr>
</thead>
</table>
| **Securing Mastery Goals** | 3.1.4 Pressure acts in a fluid in all directions. It increases with depth due to the increased weight of fluid, and results in an upthrust.  
- 3.1.4 Use the formula: fluid pressure, or stress on a surface = \( \text{force (N)} \pad{2} \text{area (m}^2\text{)} \)  
- 3.1.4 Use diagrams to explain observations of fluids in terms of unequal pressure.  
- 3.1.4 Given unfamiliar situations, use the formula to calculate fluid pressure or stress on a surface. |

**Know** | - Describe the motion of particles in a fluid.  
- Calculate fluid pressure with support.  
- State the cause of atmospheric pressure. |

**Apply** | - Explain why fluids exert a pressure.  
- Calculate fluid pressure.  
- Describe how atmospheric pressure changes with height. |

**Extend** | - Explain a range of observations in terms of fluid pressure.  
- Calculate fluid pressure in a range of situations.  
- Predict the changes to the effects of atmospheric pressure. |

To start, use partially inflated balloons to introduce gas pressure and explain what causes gas pressure. Discuss how gas and liquids are both fluids. Display objects under pressure, (e.g. aerosol cans) and ask students to suggest what these objects have in common. Ask students to explain in terms of particles what is happening.

For the main lesson activity, demonstrate the collapsing bottle experiment to the class with boiling water. Ask students to suggest what has happened to the bottle in terms of pressure, before offering the answer. Students draw diagrams to illustrate their answer. An additional demonstration is to show the difficulty in pulling out the plunger of an empty but sealed syringe. Students note down their observations of these two demonstrations on their activity sheets and answer the questions that follow.

For plenary, students reorder phrases on the interactive resource to explain what happens during the collapsing bottle experiment. Students complete a calculation of fluid pressure. **Support:** Students should have access to a structured sheet to help with the calculations.

For homework, students write a paragraph on 'Atmospheric pressure at work'. An alternative WebQuest homework activity is also available on Kerboodle.
<table>
<thead>
<tr>
<th>1.4.2 Pressure in liquids</th>
<th>Pressure at different altitudes or temperatures.</th>
<th>To start, ask if a kilogram of feathers or a kilogram of iron weighs more, correcting misconceptions. Introduce the idea of water pressure and how this relates to floating and sinking. Students discuss, with reasons, how water pressure changes moving down to the bottom of a swimming pool. For the main lesson activity, explain floating and sinking in terms of pressure and upthrust force. Students should then practise drawing force diagrams using upthrust and weight arrows to illustrate floating and sinking. Students predict whether a range of objects will float or sink in water. Show students the drinks bottle with holes at various heights, and explain that the bottle will be filled with water to show water pressure at work. Students should fill in the prediction section of the activity sheet, watch the demonstrations, and answer the questions that follow. For plenary, students predict if an orange floats when it is unpeeled (yes) and peeled (no). Demonstrate this experiment and ask students to explain their observations. Students fill in the missing words on the interactive resource to explain water pressure in different scenarios.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Securing Mastery Goals</strong></td>
<td><strong>Know</strong> - State simply what happens to pressure with depth. - Describe characteristics of some objects that float and some that sink. - Write down the equation for calculating fluid pressure. <strong>Apply</strong> - Describe how liquid pressure changes with depth. - Explain why some things float and some things sink, using force diagrams. - Use the equation for calculating fluid pressure.</td>
<td><strong>Activity:</strong> Liquids at work  <strong>Interactive:</strong> Water pressure</td>
</tr>
<tr>
<td>- 3.1.4 Pressure increases with depth due to the increased weight of fluid, and results in an upthrust. Upthrust depends on area. - 3.1.4 Explain why objects either sink or float depending upon their weight and the upthrust acting on them. - 3.1.4 Explain observations where the effects of forces are different because of differences in the area over which they apply. - 3.1.4 Given unfamiliar situations, use the formula to calculate fluid pressure or stress on a surface.</td>
<td><strong>Exceeding Mastery Goals</strong> - 3.1.4 Use the idea of pressure changing with depth to explain underwater effects.</td>
<td></td>
</tr>
</tbody>
</table>
### Five year scheme of work

**1.4.3 Stress on solids**

<table>
<thead>
<tr>
<th>Securing Mastery Goals</th>
<th>Know</th>
<th>Apply</th>
<th>Exceeding Mastery</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 3.1.4 Different stresses on a solid object can be used to explain observations where objects scratch, sink into, or break surfaces. - 3.1.4 Use the formula: fluid pressure, or stress on a surface = ( \frac{\text{force (N)}}{\text{area (m}^2)} ) - 3.1.4 Given unfamiliar situations, use the formula to calculate fluid pressure or stress on a surface.</td>
<td>- State the equation of stress. - Use ideas of stress to describe familiar situations qualitatively. - Predict qualitatively the effect of changing area and/or force on stress.</td>
<td>- Calculate stress. - Apply ideas of stress to different</td>
<td></td>
</tr>
</tbody>
</table>

**Extend**
- Explain why liquid pressure changes with depth.
- Explain why an object will float or sink in terms of forces or density.
- Use the equation for calculating fluid pressure to explain how hydraulic machines work.

For homework, students answer simple questions about the effects of pressure in liquids.

An alternative question-led lesson is also available.

To start, students suggest ways to walk through soft snow, e.g. using snow shoes. Explain how these ideas reduce stress on the snow, introducing the idea of stress and the stress equation.

**Support:** Ask structured questions, for example, would you rather wear stiletto heels or snow boots when walking in snow?

Students discuss why a drawing pin has a sharp point at one end and a flat head at the other, explain the force.

For the main lesson activity, introduce the idea of stress as the force exerted by one solid on another. Demonstrate how changing the force or the area of an object affects the stress. Try simple calculations on the board using the equation, and ask students to carry out.
**Goals**
- 3.1.4 Use the idea of stress to deduce potential damage to one solid object by another.

**Enquiry processes**
- 2.3 Suggest a scientific reason for your findings.
- 2.12 Make an experimental prediction.

**Enquiry processes activity**
- 3.1.4 Investigate how pressure from your foot onto the ground varies with different footwear.

<table>
<thead>
<tr>
<th>Situations</th>
<th>Predict quantitatively the effect of changing area and/or force on stress.</th>
<th>Predict quantitatively the effect of changing area and/or force on stress in a range of situations.</th>
<th>Calculate stress in multistep problems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extend</td>
<td></td>
<td></td>
<td>Extend</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Compare stress in different situations, explaining the differences in pressure using scientific knowledge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Predict quantitatively the effect of changing area and/or force on stress.</td>
</tr>
</tbody>
</table>

Students then carry out a short experiment to investigate stress exerted by different types of footwear, using a tray of sand or modelling clay. Students should look for patterns in their results and attempt the questions that follow.

For plenary, students categorise a list of scenarios on the interactive resource according to whether high stress or low stress is useful. Students carry out simple calculations to work out the stress exerted by different students when wearing different types of shoes.

For homework, students find other examples of useful stress in everyday life.
AQA GCSE Physics

P8 Forces in balance

Guided teaching hours: 9 hours

Chapter overview

In this chapter students have compared vectors and scalars using the examples of distance and displacement along with the nature of forces. Representations of vectors using scale diagrams led to descriptions of the forces acting in a wide variety of situations and the identification of Newton’s third law. The concept of balanced and unbalanced forces was used to determine the behaviour of objects and the application of Newton’s first law of motion. Higher tier students have produced free body diagrams demonstrating the forces acting on an isolated object. The GCSE Physics students have analysed the rotational effects of forces through the idea of moments using both a mathematical approach and an investigation into the turning effect. These students also examined the application of levers and gears in increasing the size of the available force or the movement of an object. While all students determined the centre of mass of an object experimentally only the GCSE Physics students have gone further with the idea of equilibrium and have used it to analyse the equilibrium conditions in seesaws, and other objects, mathematically using a rigorous approach. All higher tier students have analysed the forces acting on an object in additional depth using a parallelogram of forces approach to determine the resultant force or a ‘missing force’ when an object is in equilibrium. In addition, the students have resolved forces at right angles to analyse systems and determine if a system is in equilibrium.

Lesson P8.1 Vectors and scalars

| AQA spec link: | 5.1.1 Scalar quantities have magnitude only. Vector quantities have magnitude and an associated direction. A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the |
| Aiming for Grade 4 LOs: | • Describe how scalars have size (magnitude) without direction. • Describe how vectors have both size (magnitude) and direction. • List some common scalars and vectors. |
| Lesson Overview | Starters | Measuring instruments (5 min) Students examine a range of measuring instruments and discuss their operation. As the crow (10 min) Interactive where students measure the direct distance between two places on a map. They then compare their value to the distance given from an Internet mapping service, |
| Resources | Activity: Scalars and vectors | Interactive: Vectors and scalars |

© Oxford University Press 2017 www.oxfordsecondary.co.uk/acknowledgements
This resource sheet may have been changed from the original.
## Five year scheme of work

### Vector quantity.

5.1.2 Force is a vector quantity.

### Aiming for Grade 6 LOs:
- Draw a scale diagram to represent a single vector.
- Categorise a wide range of quantities as either a vector or a scalar.
- Compare a scalar and a similar vector and explain how these quantities are different.

### Main

**The difference between a vector and scalar quantity** (15 min)

Discuss the similarities and differences between a distance and a displacement. Use plenty of examples such as those in the Starter 2 and the student book. Ensure that the students understand the concepts of magnitude (size) and direction. Link back to the ideas in the first starter and discuss the quantities that the instruments measure in more depth. Discuss whether these quantities are scalar or vector in nature. Can some of the instruments be used to measure both? For example, a measuring cylinder will only measure volume (always scalar) whilst a ruler may be used with a protractor to measure displacement.

**Representing vectors** (25 min) Introduce the idea of a scale diagram to discuss how vectors can be represented. Start with further examples of displacements before introducing forces. Students should attempt to draw several scaled vector diagrams from descriptive sentences (e.g., a force of 500 N acting to the left or a force of 3.2 N at an angle of 30 degrees to the horizontal). In addition, they should write a description of a vector by interpreting a diagram. Students can use the activity sheet to examine the relationship between displacement and distance in detail.

### Aiming for Grade 8 LOs:
- Interpret a scale diagram to determine the magnitude and direction of a vector.
- Translate between vector descriptions and vector diagrams and vice versa using a range of appropriate scales.
- Use a scale diagram to add two or more vectors.

### Plenaries

**Vectors and scalars** (5 min) Students complete the interactive where they choose the correct words to complete a summary of the key points from the lesson. **The shortest journey** (10 min) Use a local map and select six different locations. Ask the students to find the shortest journey that allows them to visit all six. They should estimate the total distance travelled, for example, using string and the appropriate scale.

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)

This resource sheet may have been changed from the original.
Lesson P8.2 Forces between objects

| AQA spec link: 5.1.2 A force is a push or pull that acts on an object due to the interaction with another object. |
| All forces between objects are either: • contact forces – the objects are physically touching • non-contact forces – the objects are physically separated. |

Examples of contact forces include friction, air resistance, tension, and normal contact force.

Examples of non-contact forces are gravitational force, electrostatic force, and magnetic force. Force is a vector quantity.

Students should be able to describe the interaction between pairs of objects which produce a force on each object. The forces should be represented as vectors.

| Aiming for Grade 4 LOs: • Use arrows to represent the directions of forces. • Give examples of contact and non-contact forces. • Compare the sizes of forces using the unit newton (N). |

| Lesson Overview Starters It’s a drag (5 min) Show a video of a drag racer deploying a parachute to assist in braking. Ask the students to explain how the parachute helps to slow the car down. Try and draw out the key concepts of forces and friction. |

| Force diagrams (10 min) Show a set of diagrams of objects and statements about their motion – standing still, at constant velocity or accelerating and ask the students to mark on all of the forces. Check that the students are using ‘force arrows’ and that they are marked clearly onto the point at which the force acts. |

| Main The nature of forces (15 min) Demonstrate the action of some forces by pushing and pulling some objects to show that there can be different sizes and that the direction of the force is significant. This will establish that forces are vector quantities. Students can drag a few items using a newton-meter to experience different sizes of forces. Forces between objects (25 min) Students read a passage on high diving describing the heights, times, and the potential risks involved. They use this passage to identify contact and non-contact forces, action and reaction pairs, and to explain changes in motion due to the action of forces. |

| Plenaries Pulling power (5 min) Provide students with ten (or more) force strengths of players (50 N, 100 N, 150 N, 200 N, 250 N, 300 N, 350 N, 400 N, 450 N, 500 N). Students assign them to two tug-of-war teams so that the teams are balanced. There may be several |

| Resources Activity: Forces between objects Interactive: Forces between objects |

© Oxford University Press 2017 www.oxfordschool.co.uk/acknowledgements This resource sheet may have been changed from the original.
Five year scheme of work

Lesson P8.3 Resultant forces

AQA spec link:
5.1.1 A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector quantity.
5.1.2 Force is a vector quantity.
5.1.4 A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force. Students should be able to calculate the resultant of two forces that act in a straight line.

Aim for Grade 4 LOs:
- Label a diagram showing several forces acting on an object.
- Calculate a resultant force from two parallel forces acting in opposite directions.
- State that a non-zero resultant force will cause a change in motion and a zero resultant force will not (Newton’s First Law of motion).

Aim for Grade 6 LOs:
- Draw a scaled diagram of the forces acting in a range of situations using arrows to represent the forces.
- Calculate resultant force produced by several forces acting on an object in coplanar directions.
- Describe the effect of zero and non-zero resultant forces on the motion of moving and stationary objects.

Lesson Overview
Starter
Vector addition (5 min) Develop students’ mathematical skills using addition sums that include negative numbers to check their understanding. Link this to the idea that forces are added together but ones in opposite directions are treated as negative.
Balanced forces (10 min) Show the students a toy boat floating on water and ask them to draw a diagram of all of the forces on the boat. Add small masses, one at a time, until the boat sinks. Ask them to draw a diagram showing the forces at the time when the boat was sinking.
Main
Resultant forces and their effects (25 min) Discuss with students how an object with zero resultant force will be either moving at a constant velocity or stationary. Focus on an object moving at a constant velocity, using the example of an aircraft cruising to demonstrate. Then show a video of a jet aircraft taking off and discuss the forces involved – the sound of the engines will give an indication of increasing and decreasing thrust. Emphasise the

Forces between objects (10 min) Students use the interactive to sort examples of contact and non-contact forces. They then identify the action and reaction pairs in the given scenario of a car driving at a constant speed.

Lesson P8.3 Resultant forces

AQA spec link:
5.1.1 A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector quantity. 5.1.2 Force is a vector quantity. 5.1.4 A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force. Students should be able to calculate the resultant of two forces that act in a straight line.

Students should be able to:
• describe examples of the forces acting on an isolated object or system
• use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object, including balanced forces when the resultant force is zero.

Aim for Grade 4 LOs:
- Label a diagram showing several forces acting on an object.
- Calculate a resultant force from two parallel forces acting in opposite directions.
- State that a non-zero resultant force will cause a change in motion and a zero resultant force will not (Newton’s First Law of motion).

Aim for Grade 6 LOs:
- Draw a scaled diagram of the forces acting in a range of situations using arrows to represent the forces.
- Calculate resultant force produced by several forces acting on an object in coplanar directions.
- Describe the effect of zero and non-zero resultant forces on the motion of moving and stationary objects.

Lesson Overview
Starter
Vector addition (5 min) Develop students’ mathematical skills using addition sums that include negative numbers to check their understanding. Link this to the idea that forces are added together but ones in opposite directions are treated as negative.
Balanced forces (10 min) Show the students a toy boat floating on water and ask them to draw a diagram of all of the forces on the boat. Add small masses, one at a time, until the boat sinks. Ask them to draw a diagram showing the forces at the time when the boat was sinking.
Main
Resultant forces and their effects (25 min) Discuss with students how an object with zero resultant force will be either moving at a constant velocity or stationary. Focus on an object moving at a constant velocity, using the example of an aircraft cruising to demonstrate. Then show a video of a jet aircraft taking off and discuss the forces involved – the sound of the engines will give an indication of increasing and decreasing thrust. Emphasise the

Forces between objects (10 min) Students use the interactive to sort examples of contact and non-contact forces. They then identify the action and reaction pairs in the given scenario of a car driving at a constant speed.
Aiming for Grade 8 LOs:

- Draw a scaled free-body force diagram showing forces as vectors and find the resultant force vector.
- Calculate resultant forces from several forces acting in coplanar directions using a range of SI prefixes.
- Create a detailed plan to investigate the factors that affect the acceleration of objects acted on by a non-zero resultant force.

The concept that unbalanced forces cause acceleration, which can be a change in speed or direction of motion. Students then complete the activity sheet where they apply their knowledge and understanding of zero and non-zero resultant (balanced and unbalanced) forces on three different objects – a motorbike, an aircraft, and a runner – and carry out calculations of resultant forces from forces applied on different objects.

Free-body force diagrams (15 min) The activity sheet also gives higher-tier students the opportunity to gain confidence in interpreting free-body diagrams and in describing the effects of force on different objects. They need to focus on individual objects and the forces acting on them when drawing free-body diagrams. Sketch some additional ones at this point, such as the forces acting on a boat resting on the ocean surface or a sprinter leaving the starting blocks. Two versions of each diagram can be drawn – one with all of the forces and one with just the resultant. Emphasise the term vector as opposed to arrow when describing the forces.

Plenaries

Resultant forces (10 min) Interactive where students identify true and false statements about the forces acting on a cyclist. They then identify the correct free-body diagram for a submarine moving forward and descending.

An uphill struggle (10 min) Challenge students to come up with some explanations about forces and link the ideas to energy transfer. For example, why is it harder to push a car uphill rather than on a flat road?
### Lesson P8.4 Moments at work

**AQA spec link:**
5.4 A force or a system of forces may cause an object to rotate. Students should be able to describe examples in which forces cause rotation. The turning effect of a force is called the moment of the force. The size of the moment is defined by the equation:

\[ \text{moment of a force} = \text{force} \times \text{distance} \]

Moment of a force \( M \) in newton metres, Nm
Force \( F \) in newtons, N
Distance \( d \) is the perpendicular distance from the pivot to the line of action of the force, in metres, m.

If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot. A simple lever and a simple gear system can both be used to transmit the rotational effects of forces.

#### Aiming for Grade 4 LOs:
- Give the factors that affect the size of a moment.
- Calculate the moment of a force using the appropriate equation and base units.
- Record experimental data clearly.

#### Aiming for Grade 6 LOs:
- Describe the uses of a force-multiplier lever.
- Perform calculations involving moments, including rearrangement of the equation.
- Design a system for recording data and associated calculations clearly.

#### Aiming for Grade 8 LOs:
- Explain why a force multiplier requires the effort force to move through a larger distance than the load.
- Apply the equation for a moment in a range of novel contexts including rearrangement and changes to and from base units.
- Evaluate in detail the accuracy and precision of a set of data based on comparison of measurements and a 'true value'.

#### Lesson Overview

**Starters**

**Force facts** (10 min) Students should draw a quick visual summary to show their prior knowledge about forces from KS3. This should include concepts such as forces acting in particular directions, pivots, size of forces, units, forces causing movement/acceleration, and friction.

**Right tool for the job** (10 min) Show students tools (e.g., crowbar, screwdriver, spanner) and some jobs that they are used for (e.g., opening a box or paint tin or removing a bolt). Ask the students to match each tool to appropriate jobs, and then ask the students to explain how they work.

**Main**

**Levers** (10 min) Demonstrate the use of several tools that show the application of forces and rotation, for example, removing a nail with a claw hammer, using a crowbar to lift a heavy object, using a spanner to tighten/loosen bolts. Introduce the concept of a moment as the turning effect of the force and suggest factors that will change the size of this moment.

**Investigating the turning effect of a force** (20 min) Students should carry out an investigation and clearly identify the factors that affect the size of the moment (force and distance). They design a results table that will allow recording of the force acting on the newton-meter and the weight of the masses and distance from the pivot.

**Calculating moments** (10 min) Students carry out some differentiated calculations to find moments. This can include calculation of moments produced by the moving masses in their earlier experiment and the force recorded by the newton-meter.

---

**Resources**

**Practical:**
- Investigating the turning effect of a force

**Interactive:**
- Moments at work
### Lesson P8.5 More about levers and gears

| AQA spec link: | AQA spec link:  
| 5.4 A force or a system of forces may cause an object to rotate. | Aiming for Grade 4 LOs:  
| Students should be able to describe examples in which forces cause rotation. | Identify levers being used as force multipliers.  
| The turning effect of a force is called the moment of the force. | Calculate the forces produced by force multipliers.  
| The size of the moment is defined by the equation: moment of a force = force × distance \[M = Fd\] | State that gears can be used to increase or decrease the size of forces.  
| moment of a force \(M\) in newton metres, Nm force \(F\) in newtons, N distance \(d\) is the perpendicular distance from the pivot to the line of action of the force. |  
| Lesson Overview | Lesson Overview  
| Starters | Starters  
| Elephant v. mouse (5 min) An elephant has a mass of 2000 kg, and a mouse has a mass of 10 g. If they sit on either side of a seesaw, and the elephant is 0.5 m from the pivot, how far away should the mouse sit? This can lead to a calculation of the moment from the elephant and then the distance the mouse needs to be away from the pivot (100 km). | Elephant v. mouse (5 min) An elephant has a mass of 2000 kg, and a mouse has a mass of 10 g. If they sit on either side of a seesaw, and the elephant is 0.5 m from the pivot, how far away should the mouse sit? This can lead to a calculation of the moment from the elephant and then the distance the mouse needs to be away from the pivot (100 km).  
| Odd one out (10 min) Interactive where students choose the odd one out of a series of images showing pivots and gears. | Odd one out (10 min) Interactive where students choose the odd one out of a series of images showing pivots and gears.  
| Main | Main  
| More about force multipliers (10 min) Examine the devices shown in the student book to explain the action of levers being used as force multipliers. | More about force multipliers (10 min) Examine the devices shown in the student book to explain the action of levers being used as force multipliers.  

| Lesson Overview | More about force multipliers (10 min) Examine the devices shown in the student book to explain the action of levers being used as force multipliers.  
| Starters | Starters  
| Elephant v. mouse (5 min) An elephant has a mass of 2000 kg, and a mouse has a mass of 10 g. If they sit on either side of a seesaw, and the elephant is 0.5 m from the pivot, how far away should the mouse sit? This can lead to a calculation of the moment from the elephant and then the distance the mouse needs to be away from the pivot (100 km). | Elephant v. mouse (5 min) An elephant has a mass of 2000 kg, and a mouse has a mass of 10 g. If they sit on either side of a seesaw, and the elephant is 0.5 m from the pivot, how far away should the mouse sit? This can lead to a calculation of the moment from the elephant and then the distance the mouse needs to be away from the pivot (100 km).  
| Odd one out (10 min) Interactive where students choose the odd one out of a series of images showing pivots and gears. | Odd one out (10 min) Interactive where students choose the odd one out of a series of images showing pivots and gears.  
| Main | Main  
| More about force multipliers (10 min) Examine the devices shown in the student book to explain the action of levers being used as force multipliers. | More about force multipliers (10 min) Examine the devices shown in the student book to explain the action of levers being used as force multipliers.  

| Plenaries | Plenaries  
| Moments at work (5 min) Interactive where students calculate the moment applied to turn a nut using a spanner. They then identify the gears from a bicycle that have the biggest moment. | Moments at work (5 min) Interactive where students calculate the moment applied to turn a nut using a spanner. They then identify the gears from a bicycle that have the biggest moment.  
| Weighing machine (10 min) Provide students with some object of unknown weight and ask them to use the apparatus from the investigation to find the weight. Provide the actual masses and discuss the precision and accuracy of the system. | Weighing machine (10 min) Provide students with some object of unknown weight and ask them to use the apparatus from the investigation to find the weight. Provide the actual masses and discuss the precision and accuracy of the system.  

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)  
This resource sheet may have been changed from the original.
Five year scheme of work

### Aiming for Grade 8 LOs:
- Describe the action of gears relating changes in the size of forces to the speed of rotation and the number of teeth in the gear.
- Analyse systems of gears of different ratios.
- Evaluate the results of a gear experiment, explaining any discrepancies in terms of the uncontrolled forces acting on the system.

### Simple gears (20 min)
Demonstrate the action of a set of gears using equipment or a simulation. Emphasise that the changes in distance from the shaft (pivot) allow changes in the sizes of the force linked to changes in the speed of rotation. Students then investigate the effect of different wheel diameters on an axle with this practical. They should note the additional forces that affect the results (e.g., friction on the axle) for use in evaluating the results.

### Changing gears (10 min)
Students study the application of gears in a simple engine, explaining how larger or smaller forces can be produced by differing gear combinations. An engine gear model is exceptionally valuable here, if one is available.

### Plenaries
- **Rolling on a river (10 min)**
  Show the students a paddle-boat steamer and ask them to explain how the actions of the wheel make the boat move forwards. How might gears be involved with the paddle wheel? **Distance multipliers (5 min)**
  Can the students identify any levers that increase the size of movement but reduce the size of forces?

### Lesson P8.6 Centre of mass

#### AQA spec link:
5.1.3 The weight of an object may be considered to act at a single point referred to as the object’s ‘centre of mass’.

#### Aiming for Grade 4 LOs:
- Identify the approximate centre of mass of a range of simple shapes.
- State that a suspended object will come to rest so that the centre of mass lies below the point of suspension.
- Use lines of symmetry to identify the location of the centre of mass.

#### Lesson Overview

**Starters**
- **Force diagrams (10 min)** Students label the forces on a car moving at a steady speed along a horizontal road. Discuss why the students have drawn the weight where they have. Does their force arrow show the force coming from the bottom of the car or the middle? Show that the arrows should be coming from the centre of the car, and explain that the lesson will deal with what this

---

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)
This resource sheet may have been changed from the original.
## Five year scheme of work

**Aiming for Grade 6 LOs:**
- Describe an experimental technique to determine the centre of mass of an object.
- Explain why a suspended object comes to rest with the centre of mass directly below the point of suspension in terms of balanced forces.
- Compare the stability of objects to the position of their centre of mass.

**Aiming for Grade 8 LOs:**
- Evaluate an experimental technique to determine the centre of mass of an object, identifying the likely sources of error leading to inaccuracy.
- Apply understanding of the particle model and moments to explain why objects have a point at which the mass seems to act.
- Plan a detailed investigation into the stability of three-dimensional objects.

---

**Fearful symmetry** (5 min) Give students a set of shapes (rectangle, square, equilateral triangle, isosceles triangle, circle) and ask them to draw on the shapes the lines of symmetry. Discuss whether the point at which these lines cross is the centre.

**Main**

**Centre of mass** (40 min) Discuss the concept of the ‘middle’ of objects in terms of where the mass of an object seems to be. This is a simplification of all of the individual masses of the particles within the object. Demonstrate suspending some objects to show that they align themselves in particular ways and that there is a point that is always directly below the suspension point. Secure a clamp to a desk, and students suspend the objects from the stand using string. Suspend the same object from several different points to show roughly where the centre of mass is. Show the students, or allow them to find, the position of the centre of mass of symmetrical objects by drawing the lines of symmetry and lifting the objects at this point. Students then test various objects to find their centre of mass. Start with simple geometric shapes to confirm that the centre of mass is where they expect, and then move on to irregular shapes.

**Plenaries**

**Centre of mass** (10 min) Interactive where students decide where the centre of mass is in a series of images, and then decide which item will topple over.

**Topple** (10 min) Students draw a table, listing some objects designed to topple over and some objects designed to be stable. They sketch these shapes and try to describe where the centre of mass is in each of them.
Lesson P8.7 Moments and equilibrium

AQA spec link:
5.4 The turning effect of a force is called the moment of the force.

The size of the moment is defined by the equation: moment of a force = force × distance \( M = F \times d \)

AQA GCSE

<table>
<thead>
<tr>
<th>Aiming for Grade 4 LOs:</th>
<th>Lesson Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Calculate moments using the appropriate equation.</td>
<td><strong>Starters</strong></td>
</tr>
<tr>
<td>• Define the principle of moments.</td>
<td><strong>Tipping point</strong> (5 min) Place a 50 cm ruler on a triangular pivot 20 cm from one end so that it is unbalanced. Ask the students where they could place a 20 g mass so that the ruler becomes balanced and to explain why this is.</td>
</tr>
<tr>
<td>• Find the weight of an object using a balanced beam...</td>
<td>Moments: equilibrium (10 min) Interactive where students answer questions on moments and a balanced seesaw. Students are then shown several seesaws with a variety of masses on and determine whether it is balanced or unbalanced. They must explain their reasoning; some will be using moment calculations already whilst others will be using some ‘rule of thumb’.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for Grade 6 LOs:</th>
<th><strong>Main</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use calculation of moments to determine if a seesaw is in equilibrium.</td>
<td><strong>Seesaws and balance calculations</strong> (15 min) Follow up the starters with the formal conditions for balance – equal moments in each direction. The equation and principle of moments follows logically from this. Lead the students through some differentiated example calculations to ensure they can apply the mathematical techniques to find out if the system is balanced or not.</td>
</tr>
<tr>
<td>• Apply the principle of moments to determine if an object is in equilibrium.</td>
<td><strong>Measuring an unknown weight</strong> (10 min) Place an emphasis on careful positioning to gain a precise answer in this experiment. The experiment also allows student to gain additional practice with moment calculations.</td>
</tr>
<tr>
<td>• Establish the possible range of uncertainty of a weight using repeat values.</td>
<td><strong>Measuring the weight of a beam</strong> (15 min) The second practical links together the concepts of moments and centre of mass, a recap on the second of these ideas is needed. The concept of balance is then applied to the wheelbarrow and luggage trolley.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for Grade 8 LOs:</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use calculations to determine if an object with three or more moments is in equilibrium.</td>
<td>Interactive: Moments: equilibrium</td>
</tr>
<tr>
<td>• Describe the application of moments in balance (equilibrium) in a range of contexts.</td>
<td>Maths skills: Moments</td>
</tr>
<tr>
<td>• Evaluate an experiment to determine the weight of objects in terms of accuracy and precision</td>
<td>Practical: Measuring unknown weight</td>
</tr>
</tbody>
</table>

© Oxford University Press 2017 www.oxfordsecondary.co.uk/acknowledgements
This resource sheet may have been changed from the original.
<table>
<thead>
<tr>
<th>Plenaries</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Odd one out</strong> (5 min) Support students by showing a set of diagrams of three balanced seesaws and one unbalanced one. Can they find the odd one out? They will need to perform supporting calculations.</td>
<td></td>
</tr>
<tr>
<td><strong>In balance</strong> (5 min) How can a 10 kg, a 5 kg and a 1 kg mass be balanced on a metre rule? How many combinations can the students come up with in 5 minutes?</td>
<td></td>
</tr>
</tbody>
</table>
## Lesson P8.8 The parallelogram of forces

**AQA spec link:**
5.1.4 Students should be able to:
- use free-body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object, including balanced forces when the resultant force is zero.

A single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.

**Aiming for Grade 6 LOs:**
- Find the resultant of two forces at an acute angle by drawing a scale diagram.
- Describe a system in equilibrium in which non-parallel forces are acting.
- Calculate the component of a force using scale diagrams and ratios.

**Lesson Overview**

**Starters**
*Resultant recap* (5 min) Provide the students with a few resultant force questions to refresh their understanding of adding forces. Move on to a final question where the two forces are perpendicular (e.g., 4 N at right angles to 3 N) and ask how they would find a resultant in this case.

**Main**
*Parallelogram of forces* (40 min) Recap on the idea that forces are vectors – they have magnitude and direction – by working through a few examples of parallel forces such as the tug of war. The students place a pair of force arrows head to tail so that the second arrow is at an angle to the first. They find the resultant of the two arrows using the metre rule (and the protractor if required). Students then investigate the parallelogram of forces using a zip wire. Ask student to draw force diagrams for their experiment and discuss the changes in the sizes of these forces for differences in height between the ends of the wire.

**Plenaries**
*Finding the resultant force* (10 min) Interactive where students order instructions for finding the resultant of two forces.

*Force chain* (10 min) Two students call out forces with directions, and the teacher (or nominated student) must find the resultant by drawing a scale diagram on the board. After this, another force is added onto the end, and the new resultant is found. Continue until time runs out. Restart if the resultant goes off the board.

**Aiming for Grade 8 LOs:**
- Find the resultant of two forces at an obtuse angle by drawing a scale diagram.
- Investigate non-parallel forces acting on a system in equilibrium to verify the parallelogram of forces.
- Analyse a wide range systems of non-parallel forces using a parallelogram technique.

**Resources**
*Practical:* Parallelogram of forces
*Interactive:* Finding the resultant force
# Lesson P8.9 Resolution of forces

**Lesson Overview**

**Starters**
- **Slide** (5 min) Show some video footage of various slides, and ask the students to explain the motion of the people on them. Look for explanations about why the people are accelerating (unbalanced forces) and why they reach constant speeds (balanced force) or end up stuck.
- **Direction sense** (10 min) Students should translate prose descriptions of forces (e.g., ‘a 20 N force acting at 30 degrees to the horizontal’) into figures and vice versa to develop their ability to describe forces precisely.

**Main**
- **Resolving vectors** (10 min) Demonstrate the idea of breaking down a force into components by showing that any one force can be represented by two forces acting at right angles. Cardboard force arrows can assist with this.
- **Testing an incline** (20 min) Students can try this experiment to see that the force increases with the weight of the trolley. A simple mathematical model should show that doubling the weight doubles the force. It is likely that this will not be exactly true because frictional effects increase with the weight of the trolley.
- **Equilibrium** (10 min) Students analyse a system at equilibrium in detail, as shown in the student book, to ensure they are aware of the conditions required for equilibrium. This needs to be a methodical treatment of this demanding situation.

**Plenaries**

## Aiming for Grade 6 LOs:
- Resolve a single force into two perpendicular components.
- Determine if an object is in equilibrium by considering the horizontal and vertical forces.
- Investigate the effect of increasing the weight of an object on a slope on the component of the weight acting along the slope.

## Aiming for Grade 8 LOs:
- Resolve a pair of forces into the overall perpendicular components.
- Determine if an object is in equilibrium by considering the horizontal and vertical components of forces.
- Plan a detailed investigation into the effect of...
### Five year scheme of work

<table>
<thead>
<tr>
<th>Increasing the gradient of a slope on the component of the weight acting along the slope.</th>
<th>Resolving a force (10 min) Interactive where students resolve components of forces acting in different directions. <strong>How long is a piece of string?</strong> (5 min) Give each student a length of string and ask the student to stick it on to a sheet of squared paper in a random diagonal direction. The students then resolve the string into horizontal and vertical components, writing down these values.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Lesson P8 Forces in balance checkpoint</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for Grade 4 LOs:</strong></td>
</tr>
<tr>
<td>- Describe what is meant by a resultant force.</td>
</tr>
<tr>
<td>- State how the centre of mass is linked to stability.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Lesson Overview</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starter</strong></td>
</tr>
<tr>
<td>Make the force! (5 min) Give out diagrams with arrows showing forces on them. The arrows should be recognisably 1 unit, 2 units, and 3 units in length. Call out a force and ask them to hold up two arrows that produce that resultant force.</td>
</tr>
<tr>
<td><strong>How stable?</strong> (5 min) Give out a selection of diagrams of objects that are stable, unstable, and have neutral stability. In small groups, ask students to put them in order of most to least stable. Pair groups together and ask them to compare their orders, and discuss the best explanation for the order.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mains</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for 4</strong></td>
</tr>
<tr>
<td>Aiming for 4 students use the Checkpoint follow-up sheet to investigate adding forces to produce a resultant force and to investigate how the stability of a box depends on the mass</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Progress</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for 4</strong></td>
</tr>
<tr>
<td>Encourage students to review a series of objects and describe their stability.</td>
</tr>
<tr>
<td><strong>Aiming for 6</strong></td>
</tr>
<tr>
<td>Encourage students to calculate the components of a force using trigonometry and check their results using a scale diagram.</td>
</tr>
<tr>
<td><strong>Aiming for 8</strong></td>
</tr>
<tr>
<td>Encourage students to practise using the parallelogram of forces to find resultant forces.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Resources</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity:</strong> P8 Checkpoint follow up: Aiming for 4</td>
</tr>
<tr>
<td><strong>Activity:</strong> P8 Checkpoint follow up: Aiming for 6</td>
</tr>
<tr>
<td><strong>Activity:</strong> P8 Checkpoint follow up: Aiming for 8</td>
</tr>
</tbody>
</table>
Aiming for Grade 8 LOs:
- Use the parallelogram of forces to find a resultant force.
- Explain why some objects are stable and others topple.

inside a box. The follow-up sheet provides structured tasks and questions to help them complete these activities and check their understanding of resultant forces and stability.

Aiming for 6
Aiming for 6 students use the Checkpoint follow-up sheet to find an unknown mass using a seesaw and the law of moments, and to investigate how the stability of a box depends on the mass inside a box. The Aiming for 6 Checkpoint follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of moments, stability, and resolving forces.

Aiming for 8
Aiming for 8 students use the Checkpoint follow-up sheet to model the stability of a lorry on a slope, and to model removing a fence post from the ground using a tractor. The Aiming for 8 Checkpoint follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of moments, stability, resolving forces, and the parallelogram of forces.

Plenary
Make the forces again (10 min) Use the same arrows from the starter activity. Aiming for 4 students should find as many different resultant forces as they can from the arrows they are given.

Against the wall! (5 min) Students should work in pairs. One student should stand against the wall so that they are close enough that their back and legs are touching it. The other student should place a chair in front of them, and ask them to reach down and pick it up. They swap, and then discuss why it is not possible. Discuss the ideas with the class, and the link between moments and stability.
P9 Motion

Guided teaching hours: 4 hours

Chapter overview

In this chapter the students have analysed the motion of objects in depth starting from a recap of the concept of speed and this relationship to distance travelled and time taken. The representation of motion using distance-time graphs representing single and multiple objects has been analysed to give detailed descriptions of the movement of the objects.

The students have defined acceleration in terms of changes in velocity before analysing it graphically and mathematically. Higher tier students have also outlined circular motion in terms of constant acceleration but with constant speed. All students have then investigated acceleration caused by an unbalanced force on ramp, linking acceleration to the gradient of a line on a velocity-time graph.

Students have continued to analyse graphs representing motion by looking at the area beneath the line on a velocity-time graph and its relationship to the distance travelled by an object. Students have used the gradient of a distance-time graph to determine the speed of an object. In addition, higher tier students have used the tangent of a line on a distance-time graph to determine the speed. All students have then applied these techniques to analyse a range of graphs to extract all of the possible information from them.

Lesson P9.1 Speed and distance–time graphs

AQA spec link:

5.6.1.1 Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity.

5.6.1.2 Speed does not involve direction. Speed is a scalar quantity. The speed of a moving object is rarely constant. When people walk, run, or travel in

Aiming for Grade 4 LOs:

- Describe how the gradient of a distance–time graph represents the speed.
- Estimate typical speeds for walking, running, and cycling.
- Calculate the distance an object at constant speed will travel in a given time.

Lesson Overview

Starters

Speed, velocity, and acceleration graphs (10 min) Ensure the students can interpret a simple graph of motion by matching data with a graph. They should identify the gradient and note that it is constant when the distance is changing by a fixed amount each second.

Resources

Interactive: Speed, velocity, and acceleration graphs
Activity: Distance–time graphs
a car their speed is constantly changing.

The speed at which a person can walk, run, or cycle depends on many factors including: age, terrain, fitness, and distance travelled.

Typical values may be taken as: walking 1.5 m/s, running 3 m/s, cycling 6 m/s.

For an object moving at constant speed the distance travelled in a specific time can be calculated using the equation:

\[ s = v \times t \]

where

- \( s \) = distance travelled in metres, m
- \( v \) = speed in metres per second, m/s
- \( t \) = time in seconds, s

5.6.1.4 If an object moves along a straight line, the distance travelled can be represented by a distance–time graph. The speed of an object can be calculated from the gradient of its distance–time graph.

### Aiming for Grade 6 LOs:
- Use the gradients of distance–time graphs to compare the speeds of objects.
- Describe the motion of an object by interpreting distance–time graphs.
- Calculate the speed of an object and the time taken to travel a given distance.

### Speedy start (5 min)
Give students different moving objects, and ask them to put the objects in order from fastest to slowest. Provide data on the objects so that the students can actually work out the speed of the objects using the speed equation. Examples could be a worm (0.5 cm/s), human walking (0.5 m/s), bicycle (5 m/s), car (20 m/s), passenger aircraft (200 m/s), and missile (1 km/s).

### Main
Aiming for Grade 8 LOs:
- Calculate the speed of an object by extracting data from a distance–time graph.
- Extract data from a distance–time graph to calculate the speed of an object at various points in its motion.
- Perform calculations of speed, distance, and time which involve conversion to and from SI base units.

### Distance–time graphs (40 min)
Students try a few example speed calculations based on the equation. Use examples that lead to typical walking (1.5 m/s), running (3 m/s), and cycling speeds (6 m/s) as students are expected to recall these values. Students then complete the activity sheet where they analyse a distance–time graph of a motorbike, describing when it was travelling at the slowest speed, and extracting simple data from the graph to find speed in different phases of motion.

### Plenaries
#### Timetable (5 min)
Provide the students with a graph and ask them to describe the motion of the object in prose and calculate the speed of the object during each stage of the motion.

#### A driving story (10 min)
Provide students with a paragraph describing the motion of a car through a town, including moving at different speeds and stopping at traffic lights, and so on. Ask them to sketch a graph of the described motion.
### Lesson P9.2 Forces between objects

**AQA spec link:**
5.6.1.3 The velocity of an object is its speed in a given direction. Velocity is a vector quantity. Students should be able to explain the vector–scalar distinction as it applies to displacement, distance, velocity, and speed.

5.6.1.4 If an object moves along a straight line, the distance travelled can be represented by a distance–time graph.

- Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity.

**Lesson Overview**

- **Starters**
  - Getting nowhere fast (5 min) A racing driver completes a full circuit of a 3 km racetrack in 90 seconds. Ask what is his average speed? Why aren’t they 3 km away from where they started? Use this idea to explain the difference between distance travelled and displacement.
  - Treasure island (10 min) Provide the students with a scaled map with a starting point, hidden treasure, protractor, and ruler. At first, only give them the times they have to walk for, then the speeds they must go at, and finally the matching directions. See which group can find the treasure first. This shows how important direction is when describing movement.

- **Main**
  - Defining velocity (15 min) Use plenty of examples involving the description of the direction of motion as students can struggle with the difference between speed and velocity.
  - Acceleration (25 min) Students will understand acceleration to mean **getting faster**. Use this as a starting point and move towards the idea that it is possible to find out how much faster each second. This leads to the formal equation. The students will need to try several example calculations at this point. Ensure they can identify starting or end velocities of zero in the questions (e.g., at

**Aiming for Grade 4 LOs:**
- Describe the difference between speed and velocity using an appropriate example.
- Give the equation relating velocity, acceleration, and time.
- Calculate the acceleration of an object using the change in velocity and time.

**Aiming for Grade 6 LOs:**
- Identify the features of a velocity–time graph.
- Rearrange the acceleration equation in calculations.
- Calculate the change in velocity for an object under constant acceleration for a given period of time.

**Aiming for Grade 8 LOs:**
- Compare and contrast the features of a distance–time, displacement–time, and velocity–time graph.
- Combine equations relating to velocity and acceleration in multi-step calculations.
- Calculate a new velocity for a moving object that has accelerated for a given period of time.

**Resources**
- Activity: Acceleration
- Interactive: Accelerated learning

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)
This resource sheet may have been changed from the original.
### Lesson P9.3 More about velocity–time graphs

**AQA spec link:**
5.6.1.5 An object that slows down is decelerating.

- The acceleration of an object can be calculated from the gradient of a velocity–time graph.
- The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–

**Aiming for Grade 4 LOs:**
- Identify the feature of a velocity–time graph that represents the acceleration [the gradient], and compare these values.
- Identify the feature of a velocity–time graph that represents the distance travelled [the area beneath the line], and compare these values.
- Measure the acceleration of an object as it moves down a ramp.

**Lesson Overview**

**Starter**
**Late again?** (5 min) Give the students the distance from their last class to where they are now and ask them to work out their speed on the journey to you, using the time it took them to arrive. Provide some example distances from other likely rooms if students have no idea about how far it is between places.

**Finding areas** (10 min) Ask the students to calculate the total area

**Plenaries**

**Comparing graphs** (10 min) Ask the students to make a comparison of what a distance–time graph and a velocity–time graph show. They should produce a chart/diagram highlighting the distinctions between what the features of these graphs represent.

**Accelerated learning** (10 min) The students should try a few additional acceleration questions. Differentiate these so that there are several stages of calculation in some of the questions.

**Resources**
- Practical: Investigating acceleration
- Interactive: Matching motion

---

**Students should be able to determine speed from a distance–time graph.**

- Students use the term deceleration in a description of an object slowing down to make sure they understand it.

---

**Lesson Overview**

**Starter**
**Late again?** (5 min) Give the students the distance from their last class to where they are now and ask them to work out their speed on the journey to you, using the time it took them to arrive. Provide some example distances from other likely rooms if students have no idea about how far it is between places.

**Finding areas** (10 min) Ask the students to calculate the total area

**Plenaries**

**Comparing graphs** (10 min) Ask the students to make a comparison of what a distance–time graph and a velocity–time graph show. They should produce a chart/diagram highlighting the distinctions between what the features of these graphs represent.

**Accelerated learning** (10 min) The students should try a few additional acceleration questions. Differentiate these so that there are several stages of calculation in some of the questions.
### Aiming for Grade 6 LOs:
- Describe sections of velocity–time graphs, and compare the acceleration in these sections.
- Calculate the distance travelled using information taken from a velocity–time graph for one section of motion.
- Use a series of repeat measurements to find an accurate measurement of the acceleration of a moving object.

### Aiming for Grade 8 LOs:
- Calculate the acceleration of an object from values taken from a velocity–time graph.
- Calculate the total distance travelled from a multi-phase velocity–time graph.
- Evaluate an experiment into the acceleration of an object in terms of precision based on the spread of repeat measurements.

### Main
**Investigating acceleration** (25 min) After a brief recap of the concept of acceleration, the students can carry out this investigation depending on the equipment available.

**Braking** (15 min) In this activity the students look at what the features of the velocity–time graph represent. They need to clearly identify the acceleration and distance travelled as separate concepts.

Summary questions 1 to 4 in the student book will provide additional examples.

### Plenaries
**Rushed off your feet** (5 min) Wear a pedometer throughout the lesson, calculate your average step distance, and then ask the students to work out how far you have moved and your average speed. A typical example stride distance is 0.5 m with somewhere between 400 and 600 paces per lesson.

**Matching motion** (10 min) Students match velocity–time graphs with the descriptions of a car’s motion. They then interpret a velocity–time graph of an athlete during a training session.
### Lesson P9.4 Analysing motion graphs

**AQA spec link:**
5.6.1.4 The speed of an object can be calculated from the gradient of its distance–time graph.

If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.

5.6.1.5 The acceleration of an object can be calculated from the gradient of a velocity–time graph.

The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.

The following equation applies to uniform acceleration:

\[
(final \ velocity)^2 - (initial \ velocity)^2 = 2 \times \text{acceleration} \times \text{distance}
\]

\[
[v^2 - u^2 = 2as]
\]

- **Aiming for Grade 4 LOs:**
  - Identify a change in speed on a distance–time graph using change in gradient.
  - Identify a change in acceleration on a velocity–time graph using change in gradient.
  - Calculate the distance travelled by an object at constant velocity using data extracted from a graph.

- **Aiming for Grade 6 LOs:**
  - Calculate the speed of an object by extracting data from a distance–time graph.
  - Use a tangent to determine the speed of an object from a distance–time graph.
  - Use the equation \(v^2 - u^2 = 2as\) in calculations where the initial or final velocity is zero.

- **Aiming for Grade 8 LOs:**
  - Calculate the acceleration of an object by extracting data from a velocity–time graph.
  - Use the gradient of a velocity–time graph to determine the acceleration of an object.
  - Apply transformations of the equation \(v^2 - u^2 = 2as\) in calculations involving change in velocity and acceleration where both velocities are non-zero.

**Lesson Overview**

**Starters**

**Graph matching** (5 min) The students have to match the description of the movement of objects with distance–time and velocity–time graphs. Provide three different descriptions of journeys and three graphs that represent the movement for the students to match them with.

**Plot** (10 min) Give the students a set of velocity–time data for a moving object, and ask them to plot a graph of displacement against time. Check the graphs for accuracy of plotting and clear labelling of the axes.

**Main**

**Using distance–time graphs** (15 min) Lead the students through the process of determining the gradient of a line using tangents. Ensure the students can identify when the object is speeding up and when it is slowing down clearly. Students should find some velocities from example graphs to ensure they have mastered the technique.

**Velocity–time graphs** (15 min) Discuss finding acceleration from velocity–time graphs, making sure that students are aware of the difference between this type of graph and the earlier distance–time graph. Ask the students to analyse a few graphs and find acceleration using the gradient.

**Velocity–time graphs and distance travelled** (10 min) Recap the idea that the area beneath the line on the graph represents the distance travelled. This can now be linked to the mathematical equations which find the area of the shapes, noting that these are

<table>
<thead>
<tr>
<th>AQA GCSE</th>
<th>MS: 3b, 3c, 4a, 4b, 4c, 4d, 4f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity:</td>
<td>velocity–time graphs</td>
</tr>
<tr>
<td>Interactive:</td>
<td>Using graphs</td>
</tr>
</tbody>
</table>
Lesson P9 Motion checkpoint

<table>
<thead>
<tr>
<th>Aiming for Grade 4 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot a distance-time graph.</td>
</tr>
<tr>
<td>Make calculations of speed.</td>
</tr>
<tr>
<td>Interpret data on speed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for Grade 6 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot and interpret a distance-time graph.</td>
</tr>
<tr>
<td>Make calculations of speed using a range of units.</td>
</tr>
<tr>
<td>Plot and interpret a speed-time graph.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lesson Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start</strong></td>
</tr>
<tr>
<td>Faster or slower? (5 minutes) Give out some statements, such as ‘A car that travels 10 miles in half an hour is going faster than a bus that travels at 30 mph’, and ask students to sort them into true and false statements.</td>
</tr>
<tr>
<td>Walking the graph (10 minutes) Give students A4 dry wipe boards, pens and an eraser. Ask student to sketch distance time graphs of you walking. Try a variety of motions – steady speed, steady speed, stopping, steady speed. Ask them to explain how they knew how to draw each graph. You can extend the activity to speed-time graphs for Aiming for 6 students, and velocity-time graphs for Aiming for 8 students.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for 4</strong></td>
</tr>
<tr>
<td>Encourage students to think about speed as the distance travelled in each second, so distance accumulates with speed and time.</td>
</tr>
<tr>
<td><strong>Aiming for 6</strong></td>
</tr>
<tr>
<td>Encourage them to think about acceleration as the change in speed in each second, so speed accumulates with acceleration and time.</td>
</tr>
<tr>
<td><strong>Aiming for 8</strong></td>
</tr>
<tr>
<td>Resources</td>
</tr>
<tr>
<td><strong>Activity: P9</strong> Checkpoint follow up: Aiming for 4</td>
</tr>
<tr>
<td><strong>Activity: P9</strong> Checkpoint follow up: Aiming for 6</td>
</tr>
<tr>
<td><strong>Activity: P9</strong> Checkpoint follow up: Aiming for 8</td>
</tr>
</tbody>
</table>
### Aiming for Grade 8 LOs:
- Plot and interpret a distance-time graph and a speed-time graph.
- Make calculations of velocity.
- Make calculations of acceleration using tangents drawn to a curve on a velocity time graph.

### Aiming for 6
Aiming for 6 students use the Checkpoint follow-up sheet to make measurements of a ball on a track, and to do some calculations based on a 100-metre race. They also investigate the stability of a box on a ramp. The follow-up sheet provides structured tasks and questions to help them complete these activities and check their understanding of speed and acceleration, and how to interpret distance-time and velocity-time graphs.

### Aiming for 8
Aiming for 8 students use the Checkpoint follow-up sheet to investigate the speed and acceleration of a ball on a track. The follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of speed and acceleration, how to interpret distance-time and velocity-time graphs, and how to calculate acceleration from a graph where the speed is changing.

### Plenary
**Are they right?** (10 minutes) Organise students into groups of four or five and pair groups together. Give students A4 dry wipe boards, pens and an eraser. Ask each group to draw a distance-time graph that has three sections on it. They should label the axes with numbers/units, and write on the sections what the object is doing, and the speed/acceleration. Half the information should be correct, and half incorrect. The groups swap boards and use two different coloured pens to circle the correct information and the incorrect information. They swap back and evaluate the conclusions of the other group.

Encourage them to think about acceleration as the change in speed in each second, so you can calculate it using a gradient.
Five year scheme of work

P10 Forces and motion

Guided teaching hours: 9 hours

Chapter overview
Students began this chapter by experimentally determining the relationships between a force acting on an object and the acceleration, and the mass of the object and the acceleration. The results led to the formulation for Newton’s second law of motion and its application. Higher-tier students have also defined the inertial mass of an object.

The students have then compared the concepts of mass and weight, linking these through the idea of a gravitational field before looking at the forces acting on an object as it falls through a fluid and the resulting terminal velocity. The forces acting during stopping a car have been analysed; identifying two phases of the motion; thinking and braking distance and the effects of a wide range of factors on both of these distances. Students have calculated the size of the accelerations experienced during braking with higher tier students deriving an appropriate equation involving the stopping distance.

The higher tier students have investigated the concept of momentum and its conservation. Higher-tier GCSE Physics students have used the principle of conservation of momentum to allow them to determine the velocity of objects after collisions or explosion have taken place in a range of scenarios. Further analysis has allowed higher tier students to use the concept of momentum to determine the force acting during collisions and relate this to the duration of the impact. Higher-tier GCSE Physics students have also applied their knowledge of impacts to discuss the safety features of a car.

Finally, all of the students have investigated the effect of forces on the stretching of a range of materials identifying both linear and non-linear relationships between the force and extension. Students have applied Hook’s law as appropriate.

Lesson P10.1 Force and acceleration

AQA spec link:
5.6.2.1 The tendency of objects to continue in their state of rest or of uniform motion is called inertia.
5.6.2.2 Newton’s Second Law: The acceleration of an object is proportional to the resultant force.

Aiming for Grade 4 LOs:
- State the factors that will affect the acceleration of an object acted on by a resultant force.
- Calculate the force required to cause a specified acceleration on a given mass.

Lesson Overview
Starters
Accelerator (5 min) Ask the students to describe the function of the accelerator in a car.

Lift off (10 min) Interactive where students complete a description on the changes in energy stores during the

Resources
Interactive: Lift off
Practical: Investigating force and acceleration
Maths skills: Force,
<table>
<thead>
<tr>
<th><strong>Aim for Grade 6 LOs:</strong></th>
<th><strong>Aim for Grade 8 LOs:</strong></th>
<th><strong>Required practical:</strong></th>
<th><strong>Plenaries</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Describe the effect of changing the mass or the force acting on an object on the acceleration of that object.</td>
<td>• Define the inertial mass of an object in terms of force and acceleration.</td>
<td>Investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.</td>
<td>What’s wrong? (5 min) Students consider the common misconception Objects always move in the direction of the resultant force and write a corrected version.</td>
</tr>
<tr>
<td>• Perform calculations involving the rearrangement of the $F = ma$ equation.</td>
<td>• Calculate the acceleration of an object acted on by several forces.</td>
<td>Students should be able to estimate the speed, accelerations, and forces involved in large accelerations for everyday road transport.</td>
<td>I’m snookered (10 min) Students draw a series of diagrams showing the forces involved in getting out of a snooker. They draw each of the stages of the movements, showing the forces as the white ball is first hit and the collisions with the cushions.</td>
</tr>
<tr>
<td>• Combine separate experimental conclusions to form an overall conclusion.</td>
<td>• Evaluate an experiment by identifying sources of error and determining uncertainty in the resulting data.</td>
<td>Students should recognise and be able to use the symbol that indicates an approximate value or answer ~.</td>
<td></td>
</tr>
</tbody>
</table>
Lesson P10.2 Weight and terminal velocity

AQA spec link:
5.1.3 Weight is the force acting on an object due to gravity.

The force of gravity close to the Earth is due to the gravitational field around the Earth.

The weight of an object depends on the gravitational field strength at the point where the object is.

The weight of an object can be calculated using the equation:
weight \( W \) = mass \( m \) \times gravitational field strength \( g \)

weight \( W \) in newtons, N
mass \( m \) in kilograms, kg
gravitational field strength \( g \) in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength \( g \) will be given.)

The weight of an object may be considered to act at a single point referred to as the object’s ‘centre of mass’.

Aiming for Grade 4 LOs:
- State the difference between the mass of an object and its weight.
- Describe the forces acting on an object falling through a fluid.
- Investigate the motion of an object when it falls.

Aiming for Grade 6 LOs:
- Calculate the weight of objects using their mass and the gravitational field strength.
- Apply the concept of balanced forces to explain why an object falling through a fluid will reach a terminal velocity.
- Investigate the relationship between the mass of an object and the terminal velocity.

Aiming for Grade 8 LOs:
- Apply the mathematical relationship between mass, weight, and gravitational field strength in a range of situations.
- Explain the motion of an object falling through a fluid by considering the forces acting through all phases of motion.

Lesson Overview
Starters
Fluid facts (5 min) Interactive where students match up information (including diagrams) about the physical properties of solids, liquids, and gases with explanations in terms of particle behaviour. This will help them revise the states of matter and the particle theory in particular.

Aiming for Grade 6 LOs:
- Calculate the weight of objects using their mass and the gravitational field strength.
- Apply the concept of balanced forces to explain why an object falling through a fluid will reach a terminal velocity.
- Investigate the relationship between the mass of an object and the terminal velocity.

Aiming for Grade 8 LOs:
- Apply the mathematical relationship between mass, weight, and gravitational field strength in a range of situations.
- Explain the motion of an object falling through a fluid by considering the forces acting through all phases of motion.

Air resistance (10 min) Students use their understanding of particles and forces to suggest what causes air and water resistance. They should sketch the movement of objects, label the forces on them, and then try to show the particles being pushed out of the way and pushing back.

Main
Investigating falling (40 min) Demonstrate the acceleration caused by the weight of an object when there is no supporting force by dropping some objects. Discuss the unbalanced forces acting whilst they fall and when they stop. Spend a few minutes ensuring that the students are clear on the distinction between these two with some calculations of weight for different masses. Ensure the students are aware that the weight of the objects is due to a gravitational field surrounding masses. Continue with the discussion of forces focusing on drag and how this changes as the velocity increases. Students should realise that when

Resources
Interactive: Fluid facts
Extension: Getting to grips with gravitational field strength.
Practical: Investigating falling
Animation: Sky diver

© Oxford University Press 2017 www.oxfordschool.co.uk/acknowledgements
This resource sheet may have been changed from the original.
<table>
<thead>
<tr>
<th>Five year scheme of work</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The weight of an object and the mass of an object are directly proportional. Weight is measured using a calibrated spring-balance (a newton-meter).</td>
<td>• Evaluate the repeatability of an experiment by considering the spread of each set of repeat results.</td>
</tr>
<tr>
<td>the drag force matches the weight, then the object stops accelerating and so reaches terminal velocity. Use the animation to describe the changes in the forces experienced by a sky diver. Then carry out the practical to investigate falling using a model parachute. Students should investigate the effect of different masses on the time for descent. If time is limited, individual groups could investigate one mass, and then collate results as a class. As there will be considerable variability in the results, the students should focus on repeat measurements to find mean values, reducing the effects of random error.</td>
<td></td>
</tr>
<tr>
<td>Plenaries</td>
<td></td>
</tr>
<tr>
<td><strong>Top speed</strong> (5 min) Show the students a list of top speeds for cars along with some other information such as engine power and a photograph. They can discuss why the cars have a maximum speed. <strong>Falling forces</strong> (10 min) The students draw a comic strip with stick figures showing the forces at various stages of a parachute jump. This should summarise the concepts and demonstrate the changing size of the forces.</td>
<td></td>
</tr>
</tbody>
</table>
Lesson P10.3 Forces and braking

AQA spec link:
5.6.3.1 The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver’s reaction time (thinking distance) and the distance it travels under the braking force (braking distance). For a given braking force the greater the speed of the vehicle, the greater the stopping distance.

5.6.3.2 Reaction times vary from person to person. Typical values range from 0.2 s to 0.9 s.

A driver’s reaction time can be affected by tiredness, drugs, and alcohol.

Distractions may also affect a driver’s ability to react.

Students should be able to:
• explain methods used to measure human reaction times and recall typical results
• interpret and evaluate measurements from simple methods to measure the different reaction times of students
• evaluate the effect of various factors on thinking distance based on given data.

5.6.3.3 The braking distance of a vehicle can be affected by adverse road and weather conditions and poor condition of the vehicle.

Aiming for Grade 4 LOs:
- List the factors which affect the stopping distance of a car.
- Calculate the thinking distance for a car from the initial speed and reaction time.
- Estimate the relative effects of changing factors which affect the stopping distance of cars.

Aiming for Grade 6 LOs:
- Categorise factors which affect thinking distance, braking distance, and both.
- Calculate the braking distance of a car.
- Describe the relationship between speed and both thinking and braking distance.

Aiming for Grade 8 LOs:
- Calculate acceleration, mass, and braking force of vehicles.
- Calculate total stopping distance, initial speed, reaction time, and acceleration.
- Explain the relative effects of changes of speed on thinking and stopping distance.

Lesson Overview

Starter
Safety first (10 min) Use information from government safety websites about car collisions in the local area to identify accident hotspots. Link these results to the idea of speed restrictions in the area, especially around primary schools.

Stop! (5 min) To support students in understanding the wide range of factors that can affect the stopping distance of cars, provide students with a list of factors to sort according to whether they will affect stopping distances or not.

Main
Reaction time challenge (40 min) Discuss the forces acting on a car whilst it is moving at constant velocity. Reinforce the idea that the forces must balance. Identify the resistive forces clearly. The students should understand the factors affecting overall stopping distance, but they need to be clear which affects the thinking distance and which affects the braking distance.

For higher-tier students, the braking distance should be linked closely to the decelerating forces using $F = ma$ with a few example car masses and maximum braking forces. From this acceleration and the initial speed, the braking distance should be calculated. Formally introduce stopping distance to all students, ensuring that any misconceptions are corrected. Students then carry out the practical to investigate how distractions can affect your reaction times to demonstrate how using a mobile phone whilst driving can affect stopping distances. They should appreciate that...
Adverse road conditions include wet or icy conditions. Poor condition of the vehicle is limited to the vehicle’s brakes or tyres.

Students should be able to:
- explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies, and the implications for safety
- estimate how the distance required for road vehicles to stop in an emergency varies over a range of typical speeds.

5.6.3.4 When a force is applied to the brakes of a vehicle, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance.

The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

Students should be able to:
- explain the dangers caused by large decelerations
- estimate the forces involved in the deceleration of road vehicles in typical situations on a public road.

the times improve with practice and when they are fully concentrating on the clock. In a real car situation, the driver would not be able to focus on one simple task, so the times would be significantly greater.

**Plenaries**

**Stopping distances and motive forces** (10 min) Interactive where students consolidate their understanding of stopping distances. Students link together parts of sentences on braking distance, identify true and false statements on stopping distance, reaction time, and braking distance, and put a description of the forces involved as a car stops in the correct order.
### Lesson P10.4 Momentum

**AQA spec link:**
5.7.1 Momentum is defined by the equation: momentum = mass × velocity

\[ p = m \times v \]

- momentum, \( p \), in kilograms metre per second, kg m/s
- mass, \( m \), in kilograms, kg
- velocity, \( v \), in metres per second, m/s

5.7.2 In a closed system, the total momentum before an event is equal to the total momentum after the event.

This is called conservation of momentum.

**Students should be able to use the concept of momentum as a model to:**
- describe and explain examples of momentum in an event, such as a collision.

#### Aiming for Grade 6 LOs:
- Apply the equation \( p = mv \) to find the momentum, velocity or mass of an object.
- Describe how the principle of conservation of momentum can be used to find the velocities of objects.
- Investigate the behaviour of objects during explosions to verify the conservation of momentum.

#### Lesson Overview

**Starters**

**Trying to stop** (5 min) Ask students to explain why it takes a container ship several kilometres to stop but a bicycle can stop in only a few metres, even when they are travelling at the same speed.

**Stopping power** (10 min) Students use the interactive to put a list of sport balls (e.g., golf ball, cricket ball, rugby ball, and footabll) in order of difficulty to stop. They then complete a paragraph to explain what properties make it more difficult for the balls to stop. They should be able to link the stopability to the speed and mass of the balls.

**Main**

**Calculating momentum** (15 min) Introduce the concept of momentum and the equation for it by discussing a wide range of examples. The students should calculate the momentum of several objects and also the velocities of some objects when given the mass and momentum.

#### Aiming for Grade 8 LOs:
- Fully describe the motion of objects after an explosion accounting for any frictional effects.
- Apply the principle of conservation of momentum to a range of calculations involving the velocities of objects.
- Evaluate the data produced from an investigation and compare this to a theoretical framework.

**Investigating a controlled explosion** (25 min) The students should refine the details of the practical, explaining how it will demonstrate the conservation of momentum in explosions. This will involve an explanation of the different velocities of the trolleys after the collision and hence the distance they will travel in the same time. Once the data is gathered they should compare it to their predictions and suggest explanation for any differences.

#### Resources

- **Interactive:** Stopping power
- **Extension:** Understanding conservation of momentum
- **Practical:** Investigating a controlled explosion

---

© Oxford University Press 2017 [www.oxfordsecondary.co.uk/acknowledgements](http://www.oxfordsecondary.co.uk/acknowledgements)

This resource sheet may have been changed from the original.
| The skate escape (5 min) Two people are trapped on a perfectly friction free surface (e.g., an ice rink) just out of reach of each other. They are both 10 m from the edge and all that they have to help them escape is a tennis ball. Ask: how do they both escape? [Throw something from one to the other, this will give them momentum in opposite directions and they will slowly drift to the sides.]

| Boating (10 min) Discuss what happens when somebody steps on to or off of a boat but falls in the water because the boat moves away from the land. Ask the students to explain what happened, perhaps with diagrams. They should understand that the person is actually pushing the boat away. When they move left, the boat will always be forced to the right as a consequence of the conservation of momentum. |
## Lesson P10.5 Using conservation of momentum

### AQA spec link:
5.7.2 Students should be able to use the concept of momentum as a model to:
- complete calculations involving an event, such as the collision of two objects.

### Aiming for Grade 6 LOs:
- Apply the law of conservation of momentum to find the momentum before and after impacts.
- Calculate the momentum of a combination of objects after an impact.
- Evaluate data used to verify the law of conservation of momentum.

### Lesson Overview

**Starters**
- **Jumping frogs** (5 min) Position a few spring-loaded ‘jumping frog’ toys on the desk and set them off. The students need to account for changes in the energy stores before they all go off.
- **Slow motion** (10 min) Show a video of a simple explosion frame-by-frame and ask the students to explain what is happening in terms of forces, mass, and acceleration. They should see the pieces flying off in different directions – some will have greater speed than others.

**Main**
- **Conservation of momentum** (15 min) The students should analyse scenarios where trolleys move apart, performing calculations to find the velocities of the components immediately after the explosion. Students answer the summary questions in the student book for practice.
- **Investigating and analysing collisions** (25 min) Students analyse collisions using the practical. Ensure that the students are calculating the momentum before and after the impacts and comparing it. Reinforce the idea of conservation of momentum by performing some calculations supported by the worked examples in the student book. Use some additional examples that incorporate larger masses and objects moving in opposite directions.

### Aiming for Grade 8 LOs:
- Apply the law of conservation of momentum to find velocities of objects after impacts.
- Analyse the velocities of objects in a wide range of collisions.
- Evaluate an experimental technique and discuss in detail the factors which lead to differences between experimental data and an accepted law.

### Resources

**Practical:** Investigating and analysing collisions
**Interactive:** Impossibly super

### Plenaries
- **It’s against the frog** (5 min) Use a set of quick questions and the jumping frogs again. A student has the time it takes for the frog to
### Lesson P10.6 Impact forces

**AQA spec link:**
5.7.3 When a force acts on an object that is moving, or able to move, a change in momentum occurs.

The equations \( F = m \times a \) and 
\[
\begin{align*}
\Delta v = \frac{v - u}{t} \\
\Delta t
\end{align*}
\]
combine to give the equation 
\[
F = \frac{m \Delta v}{\Delta t}
\]
where \( m \Delta v \) = change in momentum
That is, force equals the rate of change of momentum.

**Aiming for Grade 6 LOs:**
- Describe collisions in terms of forces and conservation of momentum.
- Calculate the force involved in an impact from the change in momentum and time.
- Design features that will reduce the size of impact forces in a collision.

**Lesson Overview**

**Starters**

**Skids** (5 min) Why does a car take longer to stop in wet weather? Show students some pictures of cars stopping suddenly and discuss the sizes of the forces. What reduces the forces and why does this mean that the car takes a greater distance to stop?

**Sudden impact** (10 min) Arrange some bathroom tiles on the floor (inside a tray and wear safety glasses). Drop some objects onto the tiles to see if the tiles (or objects) break. These can include heavy but soft objects and a hammer. Ask the students to explain why the tiles break or why they do not.

**Main**

**Investigating impacts** (40 min) Students investigate the effect of

---

**Resources**

- **WS:** 1.2
- **MS:** 3a, 3b, 3c

- **Practical:** Investigating impacts
- **Interactive:** Owwzatt!!
**Aiming for Grade 8 LOs:**

- Apply the concept of equal and opposite forces in collisions to explain why momentum is conserved in impacts.
- Calculate changes in velocity and momentum during impacts using the force involved in the impact and the impact time.
- Plan an investigation into the impact forces involved in a collision and how they can be reduced.

This clearly shows that the forces involved in impacts are reduced by using a material that distorts. Link this to the time of impact increasing – if the impact takes place over a longer time period, then a smaller force is required to change the momentum by the same amount. Link this to the relationship $F = \frac{m \Delta v}{\Delta t}$ or $F = \frac{\Delta p}{\Delta t}$, leading to $\Delta p = F \Delta t$, to show that the relationship between the same change in momentum can be brought about by a smaller force acting over a longer time period.

The calculations here are quite complex and must be broken down into logical stages. Remind the students of some simple acceleration calculations including some decelerations as this is more important in impacts. Recap the calculation of change in momentum $(m \Delta v)$ before linking this to the size of the acting force. Students should apply this concept to a collision between vehicles. The focus should be on the equal and opposite forces acting for the same period of time. This demonstrates that the change in momentum of one object is matched by the change in momentum of another during a collision.

**Plenaries**

**Bouncy castles** (5 min) Why don’t children hurt themselves when they fall on bouncy castles? The students should draw a diagram showing why not. Check that they are identifying the forces and the timings involved.

**Owwzatt!** (10 min) How should cricketers catch fast-moving cricket balls? Students use the interactive to complete instructions explaining the science behind safely catching a cricket ball, including the reasons why gloves are used to ‘cushion’ the catch.
### Lesson P10.7 Safety first

#### AQA spec link:

5.7.3 When a force acts on an object that is moving, or able to move, a change in momentum occurs. The equations \( F = m \times a \) and \( a = (v - u) / t \) combine to give the equation \( F = (m \Delta v) \Delta t \) where \( m \Delta v \) = change in momentum

That is, force equals the rate of change of momentum.

Students should be able to explain safety features such as: air bags, seat belts, gymnasium crash mats, cycle helmets, and cushioned surfaces for playgrounds with reference to the concept of rate of change of momentum.

Students should be able to apply equations relating force, mass, velocity, and acceleration to explain how the changes involved are inter-related.

6.3.1 Students should be able to estimate how the distance for a vehicle to make an emergency stop varies over a range of speeds typical for that vehicle. Students will be required to interpret

#### Aiming for Grade 6 LOs:

- Describe the operation of some safety features of a car in simple terms.
- Report on the differences in safety features between expensive and inexpensive cars.

#### Aiming for Grade 8 LOs:

- Use scientific principles such as rate of change of momentum to explain in detail the operation of a range of car safety features.
- Evaluate a range of optional safety features based on their costs and effectiveness.

#### Lesson Overview

**Starters**

**Crash flashback** (5 min) Give the students a momentum problem to solve to refresh the ideas from Topic P10.6. Include cars or other large items as the objects involved in the collision.

**Crumpled cars** (10 min) Show the students selected photographs of crashed cars (search the Internet for images) and ask them to describe the damage they see. They should notice the crumpling effect, especially at the front or rear of the car, but may not realise that this is a deliberate design. Students then use the interactive to identify safety features of a car and the reasons why a designer would deliberately want this effect.

**Main**

**Car safety features** (30 min) Show the students a cycle helmet and discuss its features and the materials used. Link the choices to the ‘cushioning’ of an impact asking what this term means. Discuss the use of seat belts in cars, linking this concept back to reducing forces by increasing the duration of the force. Use the practical to demonstrate this.

Air bags operate in a similar way to seat belts – an increase in the collision time as the passenger pushes through the bag. This can be demonstrated by carefully dropping an egg onto a hard surface then onto a soft surface – the impact of the object on the floor is cushioned slightly. The demonstration can be expanded to include dropping an egg onto balloons inflated by different amounts – to model air bags – and dropping an egg with a crumple zone made of a paper cone. If possible, use a real child car seat to explain the features. The students should see soft materials absorb impacts and strong

#### Resources

**Interactive:** Crumpled cars

**Practical:** Car safety features

© Oxford University Press 2017 www.oxfordsecondary.co.uk/acknowledgements

This resource sheet may have been changed from the original.
**Lesson P10.8 Forces and elasticity**

<table>
<thead>
<tr>
<th>AQA spec link:</th>
<th>Aiming for Grade 4 LOs:</th>
<th>Lesson Overview</th>
</tr>
</thead>
</table>
| 5.3 Students should be able to: • give examples of the forces involved in stretching, bending, or compressing an object • explain why, to change the shape of an object (by | • State Hooke’s law. • Calculate the extension of a material using its length and original length. • Compare materials in terms of elastic and non-elastic behaviour. | **Starters**
| **Distortion** (5 min) Get the students to list the basic things that forces can do (cause acceleration, change the shape of the object). Concentrate on the forces in the diagrams that cause objects to compress or stretch, and use these to discuss whether these |

<table>
<thead>
<tr>
<th><strong>Resources</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive: In proportion</td>
</tr>
<tr>
<td><strong>Required practical:</strong> Stretch tests</td>
</tr>
</tbody>
</table>

**Five year scheme of work**

- **Emergency stop** (10 min) The students should examine and explain some numerical and graphical data on car stopping distances for different speeds.

- **Plenaries**
  - **Best car** (10 min) Give the students pictures and information about cars through the ages and get them to identify the innovations that have taken place. They can produce a timeline showing the changes. Include information about changes to maximum speeds and road types, such as the introduction of motorways.
  - **Hard sell** (10 min) The students must produce an advertisement for the expensive safety features in a new car. This could be hard-hitting or subtler in its persuasiveness. Most safety features started off as expensive accessories but as their benefits were proven, they became required by law.

**Materials maintain the shape of the seat during a collision. Ensure that you cover the advantages of placing the seat facing backwards. Finally discuss the surface used in playgrounds, showing the students some examples if these are available.**
stretches, bending, or compressing), more than one force has to be applied – this is limited to stationary objects only
- describe the difference between elastic deformation and inelastic deformation caused by stretching forces.

The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.

\[ F = k \times e \]

force \( F \) in newtons, \( N \)

spring constant \( k \) in newtons per metre, \( N/m \)

extension \( e \) in metres, \( m \)

This relationship also applies to the compression of an elastic object, where ‘\( e \)’ would be the compression of the object.

A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.

Aiming for Grade 6 LOs:
- Explain the limitations of Hooke’s law including the limit of proportionality.
- Calculate the force required to cause a given extension in a spring using the spring constant.
- Compare the behaviour of different materials under loads in terms of proportional and non-proportional behaviour.

Aiming for Grade 8 LOs:
- Find the spring constant of a spring using a graphical technique.
- Apply the Hooke’s law equation in a wide range of situations.
- Evaluate an investigation into the extension of materials in terms of the precision of the data.

changes are permanent or can be reversed.

In proportion (10 min) In this lesson the students will find a relationship that is proportional, so start the lesson by asking the students to use the interactive compare some graphs and the relationship between them. They then complete a description on the idea of proportionality.

Main

Stretch tests (40 min) Demonstrate a simple elastic band to show a material returning to its original shape showing elastic behaviour. Show the similar behaviour for a spring and then the plastic behaviour of polythene or something similar whilst also stretching a spring beyond the elastic limit to show permanent deformation.

Students then test the behaviour of materials under load using the practical. They should focus on accurate measurement of length, well organised recording of the data, and calculation of extension. When the data for the practical has been collected, graphs can be plotted to show the relationships. Identify areas where the relationship is directly proportional, ensuring the students can identify this and the limits to the behaviour.

Use the data for the spring tests to explain Hooke’s law and the associated equation. The students should find the spring constant for the spring they tested.

Plenaries

Graphical analysis (5 min) Give the students a graph showing the extension of different springs and ask them to describe the differences. They should look at the limit of proportionality and the spring constants.

Catapult (10 min) Students can explain how a catapult operates or plan an investigation measuring the energy stored in it.
### Lesson P10 Forces and motion checkpoint

<table>
<thead>
<tr>
<th>Aiming for Grade 4 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Describe the effect of force and mass on acceleration.</td>
</tr>
<tr>
<td>2. State factors that affect stopping distance.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lesson Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starter</strong></td>
</tr>
<tr>
<td>Safer cars (5 min) Show images of a range of cars from different times in history, including the most recent and Formula 1, and ask students to come up with as many different reasons as possible for improvements in car safety.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for Grade 6 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the effect of force and mass on acceleration.</td>
</tr>
<tr>
<td>2. Describe the factors that affect stopping distance.</td>
</tr>
<tr>
<td>3. Describe the behaviour of elastic materials.</td>
</tr>
</tbody>
</table>

| Faster cars (5 min) Ask students to discuss what would happen if there was a race between a motorcycle, a car, and an aeroplane. Who would win? Why? |

<table>
<thead>
<tr>
<th>Mains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for 4</strong></td>
</tr>
<tr>
<td>Aiming for 4 students use the Checkpoint follow-up sheet to model a car using a margarine tub and an elastic band, and investigate the link between force, mass, and stopping distance. The follow-up sheet provides structured tasks and questions to help them complete these activities and check their understanding of the factors affecting stopping distance, and the link between force, mass, and acceleration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiming for 6 students use the Checkpoint follow-up sheet to complete one of three activities:</td>
</tr>
<tr>
<td>1. model a car using a margarine tub and an elastic band, and investigate the link between force, mass, and stopping distance</td>
</tr>
<tr>
<td>2. investigate how the force on an elastic band affects the extension.</td>
</tr>
<tr>
<td>3. model crumple zones using a trolley.</td>
</tr>
<tr>
<td>The third activity is only appropriate for students studying AQA GCSE Physics. The follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of the link between force, mass, and acceleration, and between force and extension, as well as to apply their knowledge of forces to stopping distances and car safety.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiming for 8 students use the Checkpoint follow-up sheet to design an investigation. Students studying AQA GCSE Combined science: Trilogy design an investigation into force, mass, and acceleration. Students studying AQA GCSE Physics design an investigation either into forces, mass, and acceleration, or into the use of crumple zones in cars. The follow-up sheet provides examples of the different investigations they could design.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aiming for 4</strong></td>
</tr>
<tr>
<td>Encourage students to think about acceleration as affected by force and mass, rather than force affected by mass and acceleration.</td>
</tr>
</tbody>
</table>

| **Aiming for 6** |
| Encourage students to think about acceleration as affected by force and mass, rather than force affected by mass and acceleration, and similarly to explain the effect of force and spring constant on extension. |

| **Aiming for 8** |
| Encourage students to think about acceleration and extension as the dependent variables, and to use ideas about time of impact and momentum to explain measures to improve car safety. |

<table>
<thead>
<tr>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity: P10 Checkpoint follow up:</strong></td>
</tr>
<tr>
<td>Aiming for 4</td>
</tr>
<tr>
<td>Aiming for 6</td>
</tr>
<tr>
<td>Aiming for 8</td>
</tr>
</tbody>
</table>
tasks and questions to help them complete these activities and check their understanding of
the relationship between force, mass, and acceleration, and between force and extension, as
well as to apply their knowledge of forces to stopping distances, and to car safety, by doing
calculations involving force, momentum, and time.

**Plenary**
Stop the car (10 min) Give students A4 dry wipe boards, pens, and an eraser. Read out a
series of answers to questions about stopping distance and ask students to write the question,
for example, ‘because the friction between the wheels of the car and the road is less’.

Acceleration race (5 min) Group students by the level to which they are aiming, and give out
a pack of cards. Each card should have a picture of an object with the force acting on it and the
mass of the object. Include the motorbike, car, and aeroplane from the Starter.
Aiming for 4 students should put them in order of fastest to slowest acceleration, and Aiming
for 6/8 students should calculate the acceleration.
Aiming for 8 students should also calculate the time that would produce the same force on
each object if they are all travelling at 10 m/s.
**Five year scheme of work**

**P11 Force and pressure**

**Guided teaching hours:** 4 hours

**Chapter overview**

In this chapter the students have defined pressure as a force acting over a surface before measuring pressure and describing its effects on materials and calculating the pressure acting on a surface. Higher tier students moved on to describe the pressure in a liquid, explaining the change of pressure with depth in terms of particle behaviour, the pressure in a liquid column and the relevant equation.

Students then discussed the cause of atmospheric pressure in terms of the behaviour of particles in the air, variations in density, and temperature. They described some of the consequences of atmospheric pressure such as the suction cup and how it grips surfaces. Higher-tier students also apply the relationship between pressure, height, density, and acceleration due to gravity to determine pressures at different points in the atmosphere.

The higher-tier students continue with their examination of the effects of particles in fluids by investigating upthrust and then explaining the effect by considering the effects of differences in pressure inside the fluid. They apply the concept to explain why some objects float while others do not.

**Lesson P11.1 Pressure and surfaces**

<table>
<thead>
<tr>
<th>AQA spec link:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.1.1 A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface. The pressure at the surface of a fluid can be calculated using the equation: $p = \frac{F}{A}$</td>
</tr>
</tbody>
</table>

where:
- $p$ in pascals, Pa
- $F$ in newtons, N
- $A$ in metres squared, m²

<table>
<thead>
<tr>
<th>Aiming for Grade 4 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>State the factors that affect the pressure acting on a surface.</td>
</tr>
<tr>
<td>Calculate the pressure caused by an object resting on a surface, given the force and area of contact.</td>
</tr>
<tr>
<td>Describe how pressure can be caused by the action of fluids (liquids and gases) on a surface.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aiming for Grade 6 LOs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the effect on the pressure of changing the area of contact or weight acting on a surface.</td>
</tr>
<tr>
<td>Calculate forces or areas of contact.</td>
</tr>
<tr>
<td>Use SI prefixes in expressions for pressure as appropriate.</td>
</tr>
</tbody>
</table>

**Lesson Overview**

**Starters**

**Let it sink in** (10 min) Use a large tray of damp sand and place objects into it – some with flat surfaces and some spiky. Ask students to explain why some sink into it and others don’t. Step into the tray wearing different shoes if it is large enough.

**Hole in the wall** (5 min) Use a darts board, some darts, and some blunt objects to show that some objects will ‘stick into things’ whilst others do not. Ask the students to explain this effect.

**Main**

**Measuring pressure** (40 min) Use the conclusions of one of the starters to discuss the concept of pressure using plenty of examples such as those shown in the student book. Students will become familiar with the concept of the force acting over an area. Then introduce the equation relating pressure to force and area. Use several examples, some of which can be taken from the

**Resources**

**Practical:** Measuring pressure

**Interactive:** On thin ice
## Five year scheme of work

**Aiming for Grade 8 LOs:**
- Apply the concept of pressure in explaining the effect on a surface in a wide range of contexts.
- Perform pressure calculations including conversion of areas and forces with SI multiplier prefixes.
- Estimate uncertainty in values for pressure using experimental data.

Summary questions. Ensure that the students are comfortable with the unit for pressure (pascal) and its equivalence to the newton per square metre.

Use of the equation can be reinforced by the two practical tasks. These also serve in helping the students convert areas from square centimetres to square metres.

Examples of the wide differences in pressure and their effects should now be covered. The action of a sharp blade (e.g., a scalpel) and a blunt one (e.g., a normal cutlery knife) can be demonstrated.

### Plenaries

**On thin ice** (5 min) Interactive where students identify measures that must be taken during a rescue on an ice-covered lake and discuss the measures taken to reduce the pressure on the ice.

**If the shoe fits** (10 min) Show a range of sports and other shoes discussing their designs and how they would affect a surface. Are they designed to grip or sink into surfaces?
Lesson P11.2 Pressure in a liquid at rest

AQA spec link:
5.5.1.2 The pressure due to a column of liquid can be calculated using the equation:

\[ p = h \rho g \]

where:
- pressure \( p \) in pascals, Pa
- height of the column \( h \) in metres, m
- density \( \rho \) in kilograms per metre cubed, kg/m\(^3\)
- gravitational field strength \( g \) in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength \( g \) will be given.)

Students should be able to explain why, in a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid.

**Aiming for Grade 6 LOs:**
- Use the concept of force, mass, and volume to explain why the pressure
- Increases with depth in a liquid.
- Calculate the pressure at a point in a liquid using \( p = h \rho g \).

**Lesson Overview**

**Starters**
- **The deep** (10 min) Students use the interactive to describe the conditions deep beneath the oceans and how this relates to the design of submarines. They should realise that the pressure is very large even at fairly shallow depths.

**Leaky pipes** (5 min) Prick some small holes into a rubber Bunsen tube connected to a tap and turn it on. Ask the students to explain why no water comes out of the holes. Block the end of the tube and ask the students to explain why the water is coming out now.

**Main**
- **Pressure tests** (40 min) Explain the factors that affect the pressure at a specific depth in a liquid using the three simple demonstrations described in the practical. These effects need to be explained by discussing the forces acting at specific points – the weight of the fluid above the holes in the bottle and the pipe. This will lead onto discussion of the calculations. Link the factors discussed together to arrive at the pressure equation \( p = h \rho g \). Ensure that the students are clear on each of the terms in the equation and how the pressure would change if that factor was changed – they should be able to make statements such as if the density of the liquid increases, the pressure increases. Students should then try some calculations based on the equation.

**Plenaries**
- **Pascal's vases** (10 min) Demonstrate the behaviour of this equipment and ask the students to provide explanations for it.

**Aiming for Grade 8 LOs:**
- Use algebraic techniques to derive the equation \( p = h \rho g \).
- Rearrange the equation \( p = h \rho g \) to solve a range of questions involving the pressure in a liquid.

**Resources**
- Interactive: The deep
- Practical: Pressure tests

WS: 4.3, 4.4, 4.5, 4.6
MS: 3b, 3cc
### Lesson P11.3 Atmospheric pressure

**AQA spec link:**
5.5.2 The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.

Air molecules colliding with a surface create atmospheric pressure. The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height.

**Students should be able to:**

#### Aiming for Grade 4 LOs:
- Describe how the pressure of the atmosphere decreases with height above the Earth’s surface.
- Describe how the density of the atmosphere decreases with height.
- Describe the cause of atmospheric pressure in simple terms.

#### Aiming for Grade 6 LOs:
- Calculate the forces produced by pressure differences.
- Describe the change in pressure at different heights.
- Use the equation \( p = \rho hg \) to determine pressure in a fluid.

**Lesson Overview**

**Starter**

Tornado (5 min) Discuss why there are weather characteristics like the wind. Why does air move around the surface of the planet? What is the cause of the pressure differences in the first place?

**Lesson Overview**

Atmospheric pressure (10 min) Students complete the interactive to describe the cause of atmospheric pressure.

**Main**

Atmospheric pressure and its effects (20 min) Link back to Topic P11.2 and the factors that affect the pressure in a liquid, asking students to describe the differences between a liquid and a gas. Include a discussion of density and the motion of the particles. Discuss the motion of the particles and how these produce the

---

© Oxford University Press 2017 www.oxfordsecondary.co.uk/acknowledgements

This resource sheet may have been changed from the original.
**Five year scheme of work**

<table>
<thead>
<tr>
<th><strong>Aiming for Grade 8 LOs:</strong></th>
<th>forces that cause pressure on surfaces during collisions and link this to atmospheric pressure. Use examples such as a suction through a straw, simple breathing, suction cups, or the Magdeburg hemispheres as described in the practical.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the particle model to explain in detail the changes in atmospheric pressure.</td>
<td><strong>Modelling pressure and altitude</strong> (20 min) Discuss the changes in atmospheric pressure with altitude and use a worked example to show the forces that can result in pressure differences.</td>
</tr>
<tr>
<td>Explain a range of phenomena in terms of pressure difference.</td>
<td>Higher-tier student should relate the atmospheric pressure to the equation ( p = h \rho g ) and discuss where this is a suitable equation to determine the pressure at any height.</td>
</tr>
<tr>
<td>Explain why the relationship ( p = h \rho g ) is not suitable for calculating changes in pressure in the atmosphere over a large change in height.</td>
<td>All students should compare the equation with the pressure graphs and note that they do not match. The equation would produce a linear relationship between pressure and height. Discuss the changes in density of the air to explain the difference.</td>
</tr>
</tbody>
</table>

**5.5.1.2 The pressure due to a column of liquid can be calculated using the equation:**

\[
p = h \rho g
\]

<table>
<thead>
<tr>
<th>pressure ( p ) in pascals (Pa)</th>
<th><strong>Plenaries</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>height of the column ( h ) in metres (m)</td>
<td><strong>Suckers</strong> (5 min) Stick a suction cup toy on a window and ask student to explain why it shouldn’t be called a ‘sucker’ at all.</td>
</tr>
<tr>
<td>density ( \rho ) in kilograms per metre cubed (kg/m(^3))</td>
<td><strong>Extreme pressure</strong> (10 min) Ask students to find the change in height of a mercury column for the highest (105 360 Pa in Aberdeenshire 1902) and lowest (92 560 Pa in Perthshire 1884) recorded pressures for the UK.</td>
</tr>
<tr>
<td>gravitational field strength ( g ) in newtons per kilogram (N/kg)</td>
<td>(In any calculation the value of the gravitational field strength ( g ) will be given.)</td>
</tr>
</tbody>
</table>
Lesson P11.4 Upthrust and flotation

AQA spec link:
5.5.1.2 Students should be able to calculate the differences in pressure at different depths in a liquid. A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust.

Students should be able to describe the factors which influence floating and sinking.

Aiming for Grade 6 LOs:
- Describe the relationship between upthrust and weight for floating and submerged objects.
- Compare the density of an object with the density of a liquid to determine whether or not the object will float.
- Plan an investigation into the relationship between the average density of an object and the distance it submerges.

Lesson Overview
Starters
Will it float or will it sink? (10 min) Start the lesson by testing whether a range of objects or materials will float or sink in water using a large tank of water (e.g., a fish tank) and objects of your choice. Students should sketch simple force diagrams for both floating and sinking.

Density recap (5 min) Students should measure the density of a regular object by determining its volume and mass.

Main
Investigating upthrust (25 min) Demonstrate a floating object and discuss the forces acting on it. The students should realise that there is a force balancing the weight of the object – the upthrust. Students then use the practical to note that even objects that are sinking will have an upthrust acting on them. The cause of upthrust should be explained with reference to the equation for pressure at a depth in a liquid. Using this, show that the pressure will be greater at the bottom of an object than that at the top. Using a simple object such as a cylinder or cube will make this easier for the students to see that there will be different sizes of forces acting on the top and bottom surfaces and the resultant is the upthrust.

Density tests (15 min) Recap the concept of density if the second starter was not used, and then explain floating and sinking objects and describe why they float (or not) in terms of the upthrust provided and the weight of the object. The upthrust can then be linked to the weight of the liquid displaced. Ensure that both cases, floating and being submerged, are covered here. Some students can be led through the proof that the upthrust is equal to the weight of the fluid displaced by using the Kerboodle activity.

Aiming for Grade 8 LOs:
- Calculate the upthrust acting on a submerged object by using the pressure difference on the top and bottom surfaces.
- Use algebraic techniques to show that the weight of liquid displaced is equal to the upthrust provided.
- Carry out and evaluate in detail an investigation into the relationship between the average density of an object and the distance it submerges.

Resources
Practical:
Investigating upthrust
Extension: Floating and sinking
Interactive: the pressure is off at last

© Oxford University Press 2017 www.oxfordsecondary.co.uk/acknowledgements
This resource sheet may have been changed from the original.

65
**Lesson P11 Force and pressure checkpoint**

<table>
<thead>
<tr>
<th>Aiming for Grade 4 LOs:</th>
<th>Lesson Overview</th>
<th>Progress</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Describe how pressure is related to force and area.</td>
<td><strong>Starter</strong>&lt;br&gt;Going up! (5 min) Show a picture of a weather balloon and discuss how scientists use the balloons to make measurements of temperature, pressure, etc. in the atmosphere to help us predict the weather. Ask students to write down what they think will happen to pressure readings as the balloon goes up. Keep the description for the plenary.</td>
<td><strong>Aiming for 4</strong>&lt;br&gt;Encourage students to put units into calculations to ensure that their answer is correct.</td>
<td><strong>Activity:</strong> P11 Checkpoint follow up: Aiming for 4</td>
</tr>
<tr>
<td><strong>Aiming for Grade 6 LOs:</strong>&lt;br&gt;• Explain, in terms of force, why the atmosphere exerts a pressure.&lt;br&gt;• Describe how and why the pressure in a fluid is related to depth.</td>
<td><strong>Mains</strong>&lt;br&gt;Big pressure, small pressure (5 min) Cut an apple in half, and talk about the pressure exerted by the knife blade on the apple. Ask students to sort a series of cards showing different everyday situations into those that require a large pressure (nails, drawing pins, etc.) and those that require a small pressure (bag handles, skis, etc.).</td>
<td><strong>Aiming for 6</strong>&lt;br&gt;Encourage students to think about pressure in a fluid as related to the weight of fluid above it.</td>
<td><strong>Activity:</strong> P11 Checkpoint follow up: Aiming for 6</td>
</tr>
</tbody>
</table>

This is *not* required by the specification, but will allow students to further develop their understanding.

**Plenaries**

**Practical planning** (10 min) Students design a practical method for showing that the weight of liquid displaced is equal to the upthrust acting on an object floating or submerged in it. This can be shown by measuring the upthrust and comparing it with the weight of water displaced in a displacement can.

**The pressure is off at last** (5 min) Use the interactive to give students a series of true or false statements covering the content from the whole chapter. Students should correct the statements they identify as false.
<table>
<thead>
<tr>
<th>Aiming for Grade 8 LOs:</th>
<th>Aiming for 4 students use the Checkpoint follow-up sheet to make impressions in modelling clay and do calculations involving pressure. The follow-up sheet provides structured tasks and questions to help them complete these activities and check their understanding of pressure.</th>
<th>weight of fluid above it, and to critically evaluate models of real life situations involving pressure in fluids.</th>
<th>Aiming for 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Explain how and why atmosphere changes with height. • Explain how and why the pressure in a fluid is related to depth and density.</td>
<td>Aiming for 6 Aiming for 6 students use the Checkpoint follow-up sheet to make impressions in modelling clay and carry out calculations involving pressure. Students then investigate the link between pressure and depth in a fluid using a balloon in water. The follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of how to calculate pressure, force and area and how pressure in fluids such as liquids and gases varies with height and depth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aiming for 8 Aiming for 8 students use the Checkpoint follow-up sheet to make impressions in modelling clay and carry out calculations involving pressure, then they plot a graph of atmospheric pressure against height. Then they design an investigation to find the link between pressure and depth in the context of container ships. The follow-up sheet provides tasks and questions to help them complete these activities and check their understanding of pressure, force, and area, and how pressure in fluids such as liquids and gases varies with height and depth.</td>
<td>Plenary What’s wrong? (10 min) Give students A4 dry wipe boards, pens, and an eraser. Show a calculation of pressure that is incorrect and ask students to write the correct calculation. You can have the wrong numbers, equation, or units. Aiming for 4 students could be given the equations. Going up, going down (5 min) Return to the descriptions from the starter and ask them to write a ‘teacher’ comment on the description, and then write an explanation to go with it. Aiming at 8 students could repeat the exercise with a balloon in water being pulled down.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>