# Scheme of work

## Combined Science: Trilogy

## Physics – Forces

This resource provides guidance for teaching the Forces topic from our new GCSE in Combined Science: Trilogy/Physics (8464). It has been updated from the draft version to reflect the changes made in the accredited specification such as the specification reference numbers. There are many changes throughout the document.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 6.5 Forces

### 6.5.1 Forces and their interactions

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.5.1.1 | Scalar and vector quantities. | Scalar quantities have magnitude only.  Vector quantities have magnitude and an associated direction.  The arrow notation for vectors. | 0.5 | Describe the difference between scalar and vector quantities and give examples.  Draw vector diagrams for vectors where the size and direction of the arrow represents the size and direction of the vector. | Why is direction important when looking at forces?  Students could model displacement vectors by sketching a scale drawing for displacement vectors eg 3m East followed by 5m North in the playground. Then back in the classroom get them to draw a scale diagram (ie 1m = 1cm) of this using the arrow notation. | More able class: [Mechanics Tutorial 1 – Vectors and Scalars](http://www.antonine-education.co.uk/Pages/Physics_2/Mechanics/MEC_01/Mechanics_1.htm)  [Scalars and Vectors](http://www.physicsclassroom.com/class/1DKin/Lesson-1/Scalars-and-Vectors)  [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 6.5.1.2 | Contact and non-contact forces. | Force is a vector quantity and can be described as contact or non-contact.  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. | 1 | Gives examples of contact and non-contact forces.  Describe the effects of forces in terms of changing the shape and/or motion of objects.  Describe examples of contact forces explaining how the force is produced.  Describe examples of non-contact forces and state how the force is produced, eg gravitational force caused by two objects with mass exerting an attractive force on each other. | What do forces do to objects?  How do objects move other objects that are not in contact?  Investigate contact and non-contact forces. This can include magnets, friction along a surface eg when a shoe is pulled along a surface. You can change the surface to explore how the change affects the amount of force required to move the shoe. You could also add a lubricant eg water/oil to the surface.  Make parachutes of different sizes eg 10x10cm and one 50x50cm, then drop it from a height if available. Time how long it takes to fall and then discuss the change in forces.  Measuring the size of a force using a Newtonmeter eg from the shoe experiment above.  To illustrate static electricity as a non-contact force pupils could rub a polythene rod with a duster and then use the charged rod to attract small pieces of paper (eg from a hole punch) or bend water. | Key word Bingo – pupils make a grid 3x3 and in each of the 9 squares they write a key word from this topic. (More able classes can come up with their own words) The teacher or other pupil asks a question where the answer is one of the keywords. If it is one of their words they can cross it off – you can do first to get a row of three etc.  [Types of Forces](http://www.physicsclassroom.com/class/newtlaws/Lesson-2/Types-of-Forces)  [BBC Bitesize – Forces](http://www.bbc.co.uk/education/guides/zyydmp3/revision) |
| 6.5.1.3 | Weight and gravitational fields. | 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. | 0.5 | Describe and explain what weight is and why objects on Earth have weight.  State the units used to measure weight | Why are astronauts said to be weightless even though they are pulled down by gravity.  How do we measure weight?  Find the weight of objects within the laboratory using Newtonmeters and then their mass using laboratory balances or for heavier objects bathroom scales. | [BBC Bitesize –Weight and mass](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesvelocityrev3.shtml) |
| 6.5.1.3 | Calculating the weight of an object.  Equation for calculating the weight of an object should be known. | The weight of an object can be calculated using the equation:  weight = mass x gravitational field strength  weight, *W*, in newtons, N  mass, *m*, in kilograms, kg  gravitational field strength, *g*, in newtons per kilogram, N/kg  The weight of an object and the mass of an object are directly proportional. |  | Define weight and mass and explain the difference between them.  Calculate the weight of an object on Earth using . Rearrange this equation to find any unknown quantity.  Give the correct units of weight and mass.  Convert quantities into SI units eg grams into kilograms.  Compare the weight of an object on different planets when given the gravitational field strength of the planets.  Describe the relationship between weight and mass and what would happen to weight if mass was doubled.  Describe what is meant by ‘centre of mass’. | Would aliens living on a massive planet be smaller than humans on Earth?  How can a spring be used to find the weight of an object on Earth?  Research how the pull of gravity varies around the Earth and how this would affect the weight of a 1 kg mass.  Investigate how a spring stretches with weight. Plot a graph of the results and then using this and the extension of the spring find the weight of small objects in the lab or lumps of wood with hooks attached | [BBC Bitesize –Weight and mass](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesvelocityrev3.shtml)  [Questions on weight and mass](http://www.gcse.com/eb/gtest.htm)  Video clip: [BBC Bitesize – Relationship between planet size and gravitational field strength](http://www.bbc.co.uk/education/clips/zq22tfr) |
| 6.5.1.4 | Resultant force | 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.  Use diagrams to describe qualitatively examples where several forces lead to a resultant force on an object.  Use vector diagrams to illustrate: resolution of forces; equilibrium situations and determine the resultant of two forces including magnitude and direction. | 1 | Draw force diagrams to represent forces acting parallel to each other, both in the same direction or in opposite directions.  Calculate the resultant of a number of forces acting parallel to each other. | Are there any situations where only one force acts on an object?  Present pupils with a variety of situations and ask them to identify all of the forces acting on an object eg a car travelling along a road, a book resting on a desk, a sailing boat, a falling object.  Determine the resultant force when two forces act in a straight line. Use examples where both forces act in the same direction and situations where they are in opposite directions. | [BBC Bitesize – Zero resultant force](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/resultantforcesrev1.shtml)  Video clip: [The Effects of Forces](http://physicsnet.co.uk/gcse-physics/the-effects-of-forces-resultant-force-and-motion/) |
| 6.5.1.4 | Free body diagrams. | Use a free body diagram to show the magnitude and direction of the forces acting on an object | 0.5 | Draw free body diagrams to represent the magnitude and direction of a number of forces acting on an object. | Discuss the reasons for the use of free body diagrams to model a situation and the limitations of these diagrams in complex situations. | [Drawing Free –Body Diagrams](http://www.physicsclassroom.com/class/newtlaws/Lesson-2/Drawing-Free-Body-Diagrams)  [Forces and Motion](http://www.gcsescience.com/pfm14.htm)  [What are forces? Examples of forces](http://www.passmyexams.co.uk/GCSE/physics/forces-and-motion.html) |
| 6.5.1.4 | Resolving a single force into two components.  HT only | 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. | 1 | Draw force diagrams to show how a single force can be resolved into two components.  Calculate the horizontal and vertical component of a single force that acts on an object. | Why would splitting one force into two separate forces simplify a problem?  Pupils can attempt the following activity: Episode 201 from Institute of Physics: [Scalars and vectors](http://tap.iop.org/mechanics/static/201/page_46240.html) | [Mechanics Tutorial 1 – Vectors and Scalars](http://www.antonine-education.co.uk/Pages/Physics_2/Mechanics/MEC_01/Mechanics_1.htm)  [BBC Bitesize –Vectors: revision](http://www.bbc.co.uk/bitesize/higher/physics/mech_matt/vectors/revision/2/) |

### 6.5.2 Work done and energy transfer

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.5.2 | Calculating the work done when a force moves an object.  Equation for work done by a force should be known. | When a force causes an object to move through a distance, work is done on the object.  The work done by a force on an object can be calculated using the equation:  work done = force x distance (moved along the line of action of the force)  work done, *W*, in joules, J, force, *F*, in newtons, N distance, s, in metres | 1 | Define work done.  State the units of work.  Calculate the work done by a force on an object when given the magnitude of the force and the displacement of the object. Rearrange this equation to find any unknown value. | How much work do I do walking up the stairs?  Determine the work done against gravity by walking up a flight of stairs (or two). The work done in lifting various objects from the ground to bench level can be a variation of this theme. | [Work and energy](http://passmyexams.co.uk/GCSE/physics/work-energy.html) |
| 6.5.2 | Definition of a joule. | One joule of work is done when a force of one newton causes a displacement of one metre.  1 joule = 1 newton-metre | 0.5 | Give the standard Physics definition of work.  Equate joules with newton-metres. | For the more able pupils you could discuss base units and homogeneity of equations. The following website is useful: [Homogenous–equations](http://www.s-cool.co.uk/a-level/physics/units-quantities-and-measurements/revise-it/homogenous-equations) |  |
| 6.5.2 | Work done and energy transfer | Describe the energy transfer involved when work is done.  Work done against the frictional forces acting on an object causes a rise in the temperature of the object. | 0.5 | Describe the energy transfer involved when work is done on an object, eg the work done in lifting an object causes an increase in the gravitational potential energy store of that object. | When work is done on an object how do the energy stores change?  For various situations where work is done on an object analyse the effect of the work done, eg an increase in the GPE store or an increase in thermal energy store.  Energy circus eg kettle, microwave, hairdryer etc – pupils list the energy transfers. | [BBC Bitesize –Movement means energy](http://www.bbc.co.uk/bitesize/standard/physics/transport/movement_means_energy/revision/2/)  [Work and energy](http://passmyexams.co.uk/GCSE/physics/work-energy.html) |

### 6.5.3 Forces and elasticity

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
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| 6.5.3 | Changing the shape of an object. | Explain why a change in the shape of a stationary object (by stretching, bending or compressing) can only happen when more than one force is applied.. | 0.5 | Explain why the stretching of a material can only occur if more than one force is acting on the object  Give examples of objects being stretched, bent or compressed by forces. Draw force diagrams to show how the forces are acting on the object and how the stretching, bending or compressing occurs. | If only one force is applied to a stationary object can it be made to change shape?  Investigate the forces acting on an object that is made to change shape. Which forces are acting and in which directions? Eg a stress ball – to squeeze it you to apply forces to it in opposite directions, a spring being stretched. | [BBC Bitesize – Elastic potential energy](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forceselasticityrev1.shtml) |
| 6.5.3 | Elastic and inelastic deformation. | Elastic deformation occurs when an object returns to its original shape and size after the forces are removed. An object that does not return to its original shape after the forces have been removed has been inelastically deformed. | 1 | Define elastic deformation.  Sketch and describe the force and extension curve of an elastic material (eg elastic band or spring) when not stretched beyond its limit of proportionality.  Sketch and describe the force and extension curve of an elastic material when stretched beyond its limit of proportionality.  Interpret data from an investigation of the relationship between force and extension. And to describe the difference between a linear and non-linear relationship. | Why shouldn’t I stretch springs too much?  Investigate the effect of loading and unloading springs stretched too and beyond their limit of proportionality. Add a force of 1N (100 g mass) at a time and measure the extension of the spring. Continue until the spring is clearly stretched beyond its limit of proportionality and then remove 1N at a time, recording the extension each time. | [Elasticity](http://www.schoolphysics.co.uk/age14-16/Matter/text/Elasticity_/index.html)  Explanation of graphs. How would the graph differ if you measured length of spring rather than extension? |
| 6.5.3 | Hooke’s Law.  Equation relating the force applied to a spring and its extension should be known. | 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.  force = spring constant x extension  force, *F*, in newtons, N  spring constant, *k*, in newtons per metre, N/m  extension, *e*, in metres, m | 1 | Find the spring constant of a spring by experiment.  Sketch on an existing graph the force – extension curve for a spring with a spring constant of greater or lesser value than the spring given.  Calculate the force acting on a spring when given the spring constant and the extension of the spring. Rearrange the equation to find any missing quantity.  Evaluate the best spring to use for a given situation when given the spring constants of the springs. | Required practical :  Investigate the relationship between force and extension for a spring. (10.2.18)  Research uses of springs in compression and in tension.  Investigate the spring constants of springs in compression and in tension and analyse the data to find why high spring constants are more suited for some functions than springs with low spring constants. | Hooke’s Law  [BBC Bitesize –Hooke’s Law](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forceselasticityrev2.shtml)  Practical: [Hooke’s Law – Stretching Springs](http://www.cyberphysics.co.uk/topics/forces/hooke.htm)  Calculation of spring constant from gradient of pupils own graph and compare with the actual spring constant of the spring under investigation. If this isn’t known then the teacher is to find this prior to the pupil’s investigation. For more able pupils this can then lead to calculating % error. |

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| 6.5.3 | Work done in stretching a spring. | A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring does not go past the limit of proportionality the work done on the spring and the elastic potential energy stored are equal.  The amount of elastic potential energy stored in a stretched spring can be calculated using the equation:  (assuming the limit of proportionality has not been exceeded) elastic potential energy, Ee, in joules, J spring constant, k, in newtons per metre, N/m extension, e,  in metres, m. | 1 | Calculate the work done in stretching or compressing a spring when given the mass or weight applied to the spring.  Explain what is meant by the limit of proportionality.  Identify the limit of proportionality on a graph showing the force applied against extension.  :  Calculate the amount of energy stored by various objects including stretched springs and objects raised above the ground. | Do springs stretch in a linear manner – does doubling the force on the spring always double the extension?  Investigate the loading curve of an elastic band/spring and identify the limit of proportionality. |  |

### 6.5.4 Forces and motion

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.5.4.1.1 | Distance and displacement. | Distance is how far an object moves. It is a scalar quantity.  Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line.  Displacement is a vector quantity.  Express a displacement in terms of magnitude and direction. | 0.5 | Explain the difference between distance and displacement.  Define distance.  Define displacement.  Explain the difference between scalars and vectors and state which distance and displacement are.  Analyse both a 100m race and a 400m (one round an oval track) race. Look at how the distance and displacement changes for each race. | What is the difference between distance and displacement?  If I run a complete lap of a 400 m oval track have I gone anywhere?  Investigate how the distance travelled by a person, and their displacement, are usually different. This can be done by a modelling activity. Eg pupils walk 4 m in a straight line and then turn left and walk a further 5m. What distance have they moved and what is their displacement? This can be done both mathematically and by taking direct measurements. | [What are Distance, Displacement, Speed and Velocity?](http://www.gcsescience.com/pfm1.htm) |
| 6.5.4.1.2 | The definition of speed, how it is calculated and some typical values. | Speed is a scalar quantity.  The speed of a moving object is rarely constant. When people walk, run or travel in a car their speed is constantly changing.  The speed that 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 | 1 | Define speed and calculate it by using speed = distance/time  State that speed is a scalar quantity.  Describe the difference between average speed and instantaneous speed.  Explain why the speed of a moving object is nearly always changing.  Describe and explain the factors that affect how quickly a person can walk or run.  State typical walking, running and cycling speeds in m/s. | How fast do people walk and run? Pupils are timed walking a known distance and then their speed is calculated. This can then be extended to them running the same distance so their times can be compared.  How can we find out if cars on the road are speeding?  Investigate the speed of vehicles on roads – this can also be done with trolleys in a lab using data loggers and light gates.  Research methods used by the police/council to determine whether motorists are speeding.  Discuss whether cyclists should be charged with speeding if they are going too fast – they cannot currently be charged with speeding. | [BBC Bitesize –Speed, velocity and acceleration](http://www.bbc.co.uk/education/guides/z3bqtfr/revision) |
| 6.5.4.1.2 | Calculating the distance travelled by an object from its speed.  Equation for distance travelled should be known. | For an object moving at constant speed the distance travelled in a specific time can be calculated using the equation:  distance, *s*, in metres, m  speed, *v*, in metres per second, m/s  time, *t*, in seconds, s | 0.5 | State the equation used to find the speed of an object.  Calculate the speed of an object given the distance travelled and the time taken. Rearrange the equation to find either unknown quantity.  Analyse data about vehicle/animals travelling with different speeds, distances and times to find which object is travelling the fastest or will travel the greatest distance in a given time.  Explain how the speed of a vehicle can be found experimentally. | How does a satnav predict the time taken to reach home?  If a satellite is moving at 30,000 mph how far does it travel in a day, week and year?  Compare the distance travelled by two trolleys moving at different speeds. Which travels the furthest in a given time? If the speed is doubled what will happen to the distance travelled?  Experiment detailed above in ‘Definition of Speed’. | [BBC Bitesize –speed, distance and time](http://www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/forces/speedrev1.shtml) |
| 6.5.4.1.3 | Definition of velocity.  The velocity of an object moving around in a circle.  HT only | The velocity of an object is its speed in a given direction. Velocity is a vector quantity.  When an object moves in a circle the direction of the object is continually changing. This means that an object moving in a circle at constant speed has a continually changing velocity. | 0.5 | Define velocity.  Explain why velocity is a vector quantity rather than a scalar quantity.  Explain why an object travelling around a circular track may have a constant speed but a constantly varying velocity.  Show that the average velocity of an object around a circular track is 0 m/s. | Why is direction important when looking at collisions?  Does a vehicle with a negative velocity mean that the vehicle is reversing?  When an object moves round a track at a steady speed why is the average velocity 0 m/s? (uses idea of displacement) | [Speed and Velocity](http://www.physicsclassroom.com/class/circles/Lesson-1/Speed-and-Velocity) |
| 6.5.4.1.4 | Distance-time graphs. | If an object moves along a straight line, how far it is from a certain point can be represented by a distance–time graph.  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. HT only | 1 | Draw and interpret distance – time graphs.  Calculate the speed of an object from a distance – time graph.  Compare the speeds of two or more objects, or from one object at different points, on a distance – time graph from the gradients of the lines.  State that the steeper the line on a distance – time graph, the faster the object is travelling.  Calculate the speed of an object that is accelerating from a distance – time graph by finding the tangent to the curve at a given point then finding the gradient of the tangent. | What do the gradients of different lines on a distance-time graph represent?  How can I tell from a distance-time graph where a vehicle is moving the fastest?  How can the distance decrease on a distance – time graph when the total distance travelled has increased?  Draw distance – time graphs of a journey described by another person. Alternatively draw a distance – time graph of your journey into school and get another person to describe the journey – peer assess to see if the description is accurate. Alternatively you could model this outside by having pupils moving between certain points and the time to do that recorded as well as the distance between the points. Then back in the classroom this data can be displayed on a distance – time graph. | YouTube: [Distance-time graphs and speed](https://www.youtube.com/watch?v=9LQdLDDEJ1g)  [Displacement – Time Graphs](http://www.cyberphysics.co.uk/topics/forces/dynamics_dt.htm)  [BBC Bitesize –Force and momentum](http://www.bbc.co.uk/education/guides/z3bqtfr/revision/2) |
| 6.5.4.1.5 | Definition and calculation of acceleration.  Equation for acceleration should be known. | The average acceleration of an object can be calculated using the equation:  acceleration = change in velocity/time taken  acceleration, *a*, in metres per second squared, m/s2  change in velocity, *∆v*, in metres per second, m/s  time*, t*, in seconds, s | 1 | Define acceleration.  Calculate the acceleration of a vehicle when given the initial and final speed and the time taken for the change in speed to occur. Rearrange the equation to find other unknown quantities.  Compare the accelerations of different vehicles.  Explain how the acceleration of a vehicle can be determined experimentally. | Why do motorcycles have a greater acceleration than cars even though the engine is usually much smaller?  How can we find the acceleration of an object?  What happens to a moving object when the acceleration becomes zero?  How does the acceleration of a skydiver change from the moment the skydiver leaves the plane until they hit the ground?  Investigate the acceleration of a trolley in a lab using ticker tape or light gates. | [BBC Bitesize –Acceleration](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/forces/changingspeedrev1.shtml) |
| 6.5.4.1.5 |  | An object that slows down is decelerating. | 0.5 | Explain what deceleration means, eg a deceleration of   1.5 m/s2. | What factors affect the deceleration of a vehicle?  If a skydiver opens their parachute and decelerates, does this mean they go upwards (when a car decelerates it does not go backwards)? |  |
| 6.5.4.1.5 | Velocity-time graphs. | The acceleration of an object can be calculated from the gradient of a velocity – time graph.  The distance travelled by an object can be calculated from the area under a velocity – time graph. HT only. | 1 | Draw and interpret velocity – time graphs.  Explain how the acceleration of an object can be found from a velocity – time graph.  Compare the acceleration of a vehicle at different points of a velocity – time graph from the gradients of the lines.  Calculate the distance travelled using the area under the line on a velocity – time graph.  For velocity-time graphs that show non-uniform acceleration, measure the area under the line by counting squares. HT only | Why are the line shapes on a velocity – time graph different from those on a distance – time graph?  Why can’t we find the distance travelled by an object using speed x time if it is accelerating?  Draw a velocity – time graph for your journey into school. Compare this with a distance – time graph for the same journey. What are the differences in the line shapes? Alternatively do the activity detailed under distance-time graphs and draw velocity rather than distance. | YouTube: [Speed –time graphs & acceleration](https://www.youtube.com/watch?v=3x22CpSB7zM)  [Velocity – Time Graphs](http://www.cyberphysics.co.uk/topics/forces/dynamics_vt.htm)  [BBC Bitesize –Speed, velocity and acceleration](http://www.bbc.co.uk/education/guides/z3bqtfr/revision/4) |
| 6.5.4.1.5 | Equations of motion for uniform acceleration. | The following equation applies to uniform acceleration:  (final velocity)2 – (initial velocity)2 = 2 x acceleration x distance  final velocity, *v*, in metres per second, m/s  initial velocity, *u*, in metres per second, m/s  acceleration, *a*, in metres per second squared, m/s2  distance, s, in metres, m | 0.5 | Use the equation    to calculate the final velocity of an object at constant acceleration.  Rearrange the equation to find any unknown given the other values.  Interpret questions to find values not specifically stated, eg starts at rest means an initial velocity of 0 m/s. | What does uniform acceleration mean?  In what situations would I use rather than speed = distance/time? | [BBC Bitesize –Analysing motion: Revision](http://www.bbc.co.uk/bitesize/higher/physics/mech_matt/analyse_motion/revision/2/) |
| 6.5.4.1.5 | Falling under gravity. | Near the Earth’s surface any object falling freely under gravity has an acceleration of about 9.8 m/s2.  An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity.  Students should investigate factor/factors that affect the terminal velocity of a falling object. | 1 | Describe why objects near the Earth’s surface fall.  Describe how the forces acting on skydiver change throughout a sky dive – from jumping out of the plane to landing on the ground.  Explain how the speed of a skydiver changes throughout the dive.  Define terminal velocity.  Describe and explain factors that affect the terminal velocity of a skydiver. | Hoes does the speed a parachute falls, depend on the size of the parachute?  How does the weight attached to a parachute affect how quickly it falls?  Experiment detailed above in section ‘Contact and non-contact forces’. If a room above ground floor is available it may be possible to test to see how the weight attached to a parachute affects the rate of falling. Care needs to be taken to ensure pupil safety.  Investigate how the shape of a plasticine object affects how quickly it falls through a column of liquid. This can be changed to look at a given shape through different liquids, eg water, oil, wallpaper paste. | [Free Fall and Air Resistance](http://www.physicsclassroom.com/class/newtlaws/Lesson-3/Free-Fall-and-Air-Resistance)  [BBC Bitesize –Falling objects](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/weightfrictionrev2.shtml) |
| 6.5.4.2.1 | Newton’s First Law and the consequences of it. | Newton’s First Law:  If the resultant force acting on an object is zero and:   * the object is stationary – the object will remain stationary * the object is moving – the object will continue to move at the same speed and in the same direction. So the object continues to move at the same velocity.   So, when a vehicle travels at a steady speed the resistive forces balance the driving force.  The tendency of objects to continue in their state of rest or of uniform motion is called inertia. HT only. | 1 | State Newton’s First Law.  Describe the effect of having a zero resultant force on:   * a stationary object * an object moving at a constant velocity.   Explain that for an object travelling at terminal velocity the driving force(s) must equal the resistive force(s) acting on the object. | Newton’s First Law seems to say that if I throw an object it will keep moving in a straight line and at a steady speed but it doesn’t. Why?  What will happen to a stationary object when the forces acting on it are unbalanced? Opportunity to use light gates and data loggers. Have a trolley (initially held at rest) with a piece of string attached to one end and the other end over a pulley with weights hanging from the string. Release the trolley and use data obtained from the data loggers to examine its motion.  What will happen to a moving object when the forces acting on it become balanced? Opportunity to use the skydiver example introduced in 4.5.6.1.  What are the forces acting on a skydiver at terminal velocity?  Why do cars have a top speed?  Do more powerful engines in vehicles always mean a higher top speed?  Find out if there is a correlation between the power of a vehicles engine and its top speed? Look at motorcycles, cars and articulated lorries. | [Newton’s First Law](http://www.physicsclassroom.com/class/newtlaws/Lesson-1/Newton-s-First-Law)  [Newton’s First Law of Motion](http://www.passmyexams.co.uk/GCSE/physics/newtons-first-law-of-motion.html) |
| 6.5.4.2.2 | Newton’s Second Law.  Equation for Newton’s Second Law should be known. | Newton’s Second Law:  The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.  As an equation:  force, *F*, in newtons, N  mass, *m*, in kilograms, kg  acceleration, *a*, in metres per second squared, m/s2 | 1 | Define Newton’s Second Law.  Calculate the resultant force acting on an object using the equation  *.* Rearrange the equation to find any other unknown quantity.  Analyse data on vehicles to determine the acceleration when given the driving force and mass of the vehicle.  Explain why two identical cars that have different loads will have different accelerations.  Explain why heavier vehicles have greater stopping distances than lighter vehicles, assuming the same braking force. | What makes objects accelerate?  How can a car be accelerating if it is moving around a circle at a steady speed?  What determines how quickly a vehicle accelerates?  Why does a ball falling through a liquid have a lower acceleration than a ball falling through air?  Why is it harder to turn a loaded shopping trolley than an empty one?  Required practical  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. (10.2.19)  Investigate how the driving force of a trolley affects its acceleration. Add more mass to the pulley to change the driving force. Use light gates or ticker tape to take accurate measurements and add mass to the trolley.  Investigate how the mass of a trolley affects its acceleration. Use light gates or ticker tape to take accurate measurements and add mass to the trolley. | [Newton’s Second Law](http://www.physicsclassroom.com/class/newtlaws/Lesson-3/Newton-s-Second-Law)  [Newton’s Second – Law of Motion](http://www.passmyexams.co.uk/GCSE/physics/newtons-second-law-of-motion.html) |

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.5.4.2.2 | Inertial mass.  HT only | The tendency of objects to continue in their state of rest or of uniform motion is called inertia.  Inertial mass is a measure of how difficult it is to change the velocity of an object.  Inertial mass is defined by the ratio of force over acceleration.  For everyday road transport; estimate the speed, accelerations and forces involved in large accelerations. | 1 | Define inertial mass.  Explain why it is difficult to get a heavy moving object to change speed and/or direction but not a light one.  Estimate the speed, acceleration and forces involved in large accelerations of road transport vehicles. | How does the mass of a vehicle affect its acceleration?  Why do motorcycles have a greater acceleration than cars?  Why do cars have a higher top speed than motorcycles even though the motorcycle has less mass? | [Inertia and Mass](http://www.physicsclassroom.com/class/newtlaws/Lesson-1/Inertia-and-Mass) |
| 6.5.4.2.3 | Newton’s Third Law. | Newton’s Third Law:  Whenever two objects interact, the forces they exert on each other are equal and opposite. | 1 | Define Newton’s Third Law.  Draw force diagrams to show Newton’s third law, eg a falling object being pulled down by gravity and the Earth being pulled by the falling object. Forces need to be equal in size and opposite in direction. | Why do my feet hurt when I have been standing up for a long time?  If I drop a ball, it is pulled down but is the Earth pulled up?  Do forces always act in pairs?  Why do guns and cannons recoil when fired?  Pupils can be asked to come up with their own demonstrations eg leaning on a wall with one hand, getting off a skateboard etc. | [Newton’s Third Law](http://www.physicsclassroom.com/class/newtlaws/Lesson-4/Newton-s-Third-Law)  [Newton’s Third Law of Motion](http://www.passmyexams.co.uk/GCSE/physics/newtons-third-law-of-motion.html) |
| 4.5.6.3.1 | Thinking distance, braking distance and stopping distance. | 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. | 0.5 | Define:   * thinking distance * braking distance * stopping distance.   State that the overall stopping distance of a vehicle is made up of the thinking distance plus the braking distance.  Describe and explain how the speed of a vehicle affects the stopping distance, for a given braking force. | Why should a two second gap be left between vehicles on the road?  How will being tired affect my reaction time and thinking distance?  Why does the speed of a vehicle affect the thinking distance even though it takes the same amount of time to react?  Investigate how speed changes the stopping distance using a ramp set to different heights and a sand trap at the bottom of the ramp. Record the distance a model car travels in the sand trap before coming to rest. | [BBC Bitesize –Stopping distances](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forcesbrakingrev3.shtml)  [BBC Bitesize –Thinking, braking and stopping distance](http://www.bbc.co.uk/schools/gcsebitesize/science/add_gateway_pre_2011/forces/motionrev3.shtml)  Video clip: [Stopping distances](http://www.cyberphysics.co.uk/topics/forces/stopping_distance.htm) |
| 6.5.4.3.2 | Reaction times and thinking distance. | Reaction times vary from person to person. Typical values range from 0.2s to 0.9s.  Knowledge and understanding of methods used to measure human reaction times.  Knowledge of how a driver’s reaction time can be affected by tiredness, drugs and alcohol. Distractions may also affect a driver’s ability to react. | 1 | Estimate the typical reaction time of a person.  Describe and explain how using a mobile phone when driving will affect a driver’s reaction time and therefore their thinking distance.  Describe and explain how drugs will affect a driver’s reaction time and thinking distance.  Explain how thinking distance and reaction time are linked.  Describe methods of measuring the reaction time of a driver.  Analyse data on reaction times and use this to estimate the thinking distance of a driver. | How do drugs affect reaction times?  How does reaction time affect thinking distance?  How can reaction time be found?  Does using a mobile phone when driving affect reaction time?  Investigate how the reaction time of a person can be affected by various factors including:   * drugs (use caffeinated drinks) * distractions and * tiredness   Creative writing: Produce a leaflet to encourage motorists to switch off mobile phones before driving.  Task can be changed to look at the effects of drink driving/drug driving or to encourage the use of 20 mph zones around schools. Each task would need to link back to the effect that each has on reaction time and thinking distance. | [How do Drugs affect Driving?](https://www.emsaonline.com/mediacenter/articles/00000503.html)  Video clip: [Stopping distances](http://www.cyberphysics.co.uk/topics/forces/stopping_distance.htm) |
| 6.5.4.3.3 | Braking distance. | The braking distance of a vehicle can be affected by adverse road and weather conditions and poor condition of the vehicle.  Estimate how the distance for a vehicle to make an emergency stop varies over a range of speeds typical for that vehicle.  Interpret graphs relating  speed to stopping distance for a range of vehicles. | 0.5 | Describe factors that will affect the braking distance of a vehicle.  Explain how different factors affect the braking distance of a vehicle, eg icy roads. | Do icy and wet roads increase the braking distance of a vehicle?  Investigate how oil and water on a surface affect the level of friction on a shoe being pulled across it.  Research how the weight of a vehicle affects its braking distance.  Repeat the investigation suggested above in section ‘Thinking distance, braking distance and stopping distance’ but change the mass of the trolley/car rather than the height of the ramp. | [Braking Factors](http://www.gcse.com/fm/braking.htm) |
| 6.5.4.3.4 | Energy transfers when stopping. | 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.  Estimate the forces involved in the deceleration of road vehicles. HT only. | 1 | Describe and explain the energy transfers involved in stopping a vehicle.  Explain why vehicles travelling faster have larger braking distances.  Find patterns between the speed of a vehicle and the braking distance, eg what would be the effect of doubling the speed on the braking distance and why?  Find patterns between the speed of a vehicle and the thinking distance, eg what would be the effect of doubling the speed on the thinking distance and why?  Explain why stopping from high speed can cause the brake pads to overheat and the brake disks to warp. | Why does a drawing pin heat up when rubbed across a surface?  Why might the rims of bicycle wheels get hot when going down steep hills?  What problems are caused by brakes overheating on bicycles and cars?  Why are the brakes for a formula 1 car not suitable for road use?  Why do cars skid and why do the skid more on wet roads?  Research why vehicles skid on the road ensuring this is linked to the level of friction between the tyre and the road and the braking force applied. | [Friction, Reducing friction, Uses of friction, Stopping Distance](http://www.passmyexams.co.uk/GCSE/physics/friction-stopping-distance.html) |

### 6.5.5 Momentum (HT only)

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 6.5.5.1 | Definition and calculation of momentum.  Equation for momentum should be known. | Momentum is a property of moving objects and is defined by the equation:  momentum, *p*, in kilograms metre per second, kg m/s  mass, *m*, in kilograms, kg  velocity, *v*, in metres per second, m/s | 1 | Define momentum and recall it is a vector quantity.  State the equation that links momentum, mass and velocity.  Calculate the momentum of an object. Rearrange the equation to find any unknown quantity.  State the units of momentum.  Calculate the momentum of an object given its mass, speed and direction of movement.  Explain the importance of the minus sign for a numerical velocity in the calculation of momentum. | Why is it easier to stop a tennis ball than a football travelling at the same speed?  Why does the direction of a vehicle matter in a collision?  Demonstration of collisions along an air track to show the effect of different types of collisions or explosions. This can also be done with trolleys with a spring causing the explosion. Change the mass of each trolley to see the effect on the speed they move apart at. | [BBC Bitesize – Momentum](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/kineticenergyrev3.shtml)  [Conservation of Momentum](http://www.passmyexams.co.uk/GCSE/physics/momentum.html)  Video clip: [Momentum](http://www.cyberphysics.co.uk/topics/forces/momentum.htm) |
| 6.5.5.2 | The principle of conservation of momentum. | 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. | 1 | Explain what is meant by a closed system.  Explain what is meant by conservation of momentum.  Carry out conservation of momentum calculations for systems involving two objects, including collisions and explosions. | Why do guns and cannons recoil?  How can police investigators determine the speed of vehicles before a crash?  How does an explosion conserve momentum?  How do rockets take off?  Investigation as detailed above in section ‘Definition and calculation of momentum’. | [BBC Bitesize –Conservation of momentum](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/forces/kineticenergyrev4.shtml)  [Conservation of Momentum](http://www.cyberphysics.co.uk/topics/forces/momentum_conservation.htm) |