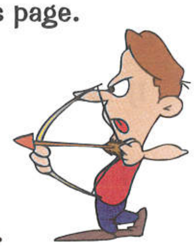
Distance, Displacement, Speed and Velocity

To understand the difference between distance and displacement, or speed and velocity, you've got to know the difference between a scalar quantity and a vector quantity. Then you can race through this page.

Vectors Have Magnitude and Direction



1) Vector quantities have a magnitude (size) and a direction.
2) Lots of physical quantities are vector quantities:

   Vector quantities: force, velocity, displacement, weight, acceleration, momentum, etc.

3) Some physical quantities only have magnitude and no direction. These are called scalar quantities:

   Scalar quantities: speed, distance, mass, energy, temperature, time, etc.

Velocity is a vector, but speed is a scalar quantity.
Both bikes are travelling at the same speed, v.
They have different velocities because they are travelling in different directions.

Distance is Scalar, Displacement is a Vector

1) Distance is just how far an object has moved. It's a scalar quantity so it doesn't involve direction.
2) Displacement is a vector quantity. It measures the distance and direction in a straight line from an object's starting point to its finishing point — e.g. the plane flew 5 metres north. The direction could be relative to a point, e.g. towards the school, or a bearing (a three-digit angle from north, e.g. 035°).
3) If you walk 5 m north, then 5 m south, your displacement is 0 m but the distance travelled is 10 m.

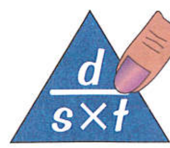
Speed and Velocity are Both How Fast You're Going

1) Speed and velocity both measure how fast you're going, but speed is a scalar and velocity is a vector:

   Speed is just how fast you're going (e.g. 30 mph or 20 m/s) with no regard to the direction.
   Velocity is speed in a given direction, e.g. 30 mph north or 20 m/s, 060°.

2) This means you can have objects travelling at a constant speed with a changing velocity. This happens when the object is changing direction whilst staying at the same speed.
3) For an object travelling at a constant speed, distance, (average) speed and time are related by the formula:

   distance travelled (m) = (average) speed (m/s) × time (s)



4) Objects rarely travel at a constant speed. E.g. when you walk, run or travel in a car, your speed is always changing. Make sure you have an idea of the typical speeds for different transport methods:

   1) Walking — 1.4 m/s (5 km/h)
   2) Running — 3 m/s (11 km/h)
   3) Cycling — 5.5 m/s (20 km/h)
   4) Cars in a built-up area — 13 m/s (47 km/h)
   5) Aeroplanes — 250 m/s (900 km/h)
   6) Cars on a motorway — 31 m/s (112 km/h)
   7) Trains — up to 55 m/s (200 km/h)
   8) Wind speed — 5 – 20 m/s
   9) Speed of sound in air — 340 m/s
   10) Ferries — 15 m/s (54 km/h)

My life's feeling pretty scalar — I've no idea where I'm headed...

This all seems pretty basic, but it's vital you understand it if you want to make it through the rest of this topic.

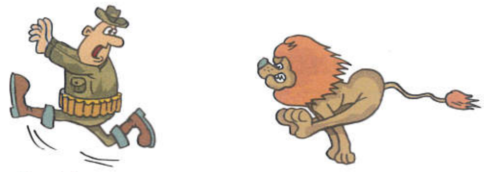
Q1 Name two examples of: a) a scalar quantity b) a vector quantity [4 marks]

Q2 A sprinter runs 200 m in 25 s. Calculate his average speed. [2 marks]

Acceleration

Uniform acceleration sounds fancy, but it's just speeding up (or slowing down) at a constant rate.

Acceleration is How Quickly You're Speeding Up



1) Acceleration is definitely not the same as velocity or speed.
2) Acceleration is the change in velocity in a certain amount of time.
3) You can find the average acceleration of an object using:

$$a = \frac{(v - u)}{t}$$

Acceleration (m/s^2)
Change in velocity (m/s) where u is the initial velocity in m/s and v is the final velocity in m/s
Time (s)

Initial velocity is just the starting velocity of the object.

4) Deceleration is just negative acceleration (if something slows down, the change in velocity is negative).

You Need to be Able to Estimate Accelerations

You might have to estimate the acceleration (or deceleration) of an object:

EXAMPLE: A car is travelling at 15 m/s, when it collides with a tree and comes to a stop. Estimate the deceleration of the car.

1) Estimate how long it would take the car to stop.
2) Put these numbers into the acceleration equation.
3) As the car has slowed down, the change in velocity and so the acceleration is negative — the car is decelerating.

The car comes to a stop in ~1 s.

$a = (v - u) \div t$
$= (0 - 15) \div 1$
$= -15$ m/s^2

The ~ symbol just means it's an approximate value (or answer).

So the deceleration is about 15 m/s^2

From the deceleration, you can estimate the forces involved too — more about that on page 16.

Uniform Acceleration Means a Constant Acceleration

1) Constant acceleration is sometimes called uniform acceleration.
2) Acceleration due to gravity (g) is uniform for objects in free fall. It's roughly equal to 10 m/s^2 near the Earth's surface and has the same value as gravitational field strength (p.17).
3) You can use this equation for uniform acceleration:

$$v^2 - u^2 = 2 \times a \times x$$

Final velocity (m/s)
Initial velocity (m/s)
Acceleration (m/s^2)
Distance (m)

EXAMPLE: A van travelling at 23 m/s starts decelerating uniformly at 2.0 m/s^2 as it heads towards a built-up area 112 m away. What will its speed be when it reaches the built-up area?

1) First, rearrange the equation so v^2 is on one side.
2) Now put the numbers in — remember a is negative because it's a deceleration.
3) Finally, square root the whole thing.

$v^2 = u^2 + (2 \times a \times x)$

$v^2 = 23^2 + (2 \times -2.0 \times 112)$
$= 81$

$v = \sqrt{81} = 9$ m/s

Uniform problems — get a clip-on tie or use the equation above...

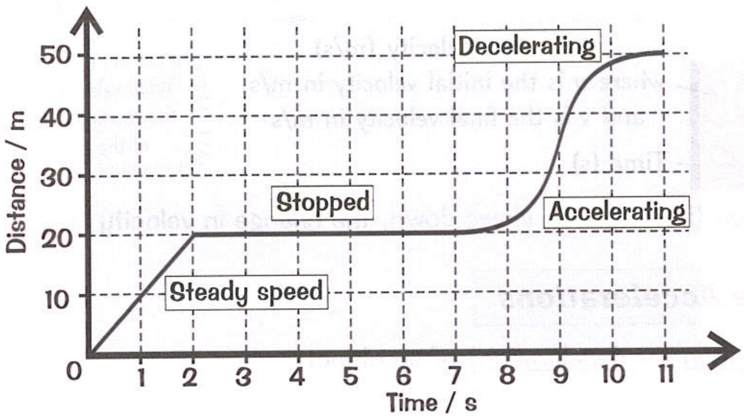
You might not be told what equation to use in the exam, so make sure you can spot when to use the equation for uniform acceleration. Make a list of the information you're given to help you see what to do.

Q1 A ball is dropped from a height, h, above the ground. The speed of the ball just before it hits the ground is 5 m/s. Calculate the height the ball is dropped from. (acceleration due to gravity ≈ 10 m/s^2) [2 marks]

Distance/Time Graphs

A graph speaks a thousand words, so it's much better than writing 'An object starts from rest and moves at a steady speed of 10 m/s for 2 s until it has reaches a distance of 20 m, then remains stationary for 5 s before increasing its velocity with a constant acceleration for 2.5 s.'

Distance/Time Graphs Tell You How Far Something has Travelled



The different parts of a distance/time graph describe the motion of an object:

- The gradient (slope) at any point gives the speed of the object.
- Flat sections are where it's stopped.
- A steeper graph means it's going faster.
- Curves represent acceleration.
- A curve getting steeper means it's speeding up (increasing gradient).
- A levelling off curve means it's slowing down (decreasing gradient).

The Speed of an Object can be Found From a Distance/Time Graph

You can find the speed at any time on a distance/time graph:

1) If the graph is a straight line, the speed at any point along that line is equal to the gradient of the line.

For example, in the graph above, the speed at any time between 0 s and 2 s is:

$$\text{Speed} = \text{gradient} = \frac{\text{change in the vertical}}{\text{change in the horizontal}} = \frac{20}{2} = 10\text{ m/s}$$

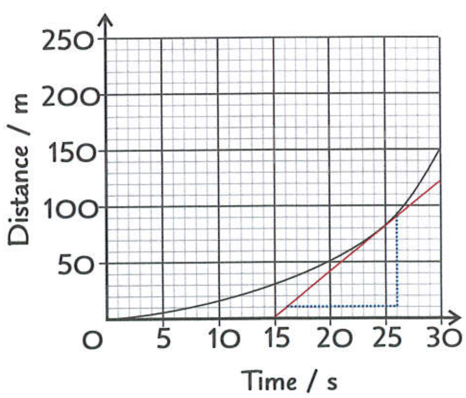
2) If the graph is curved, to find the speed at a certain time you need to draw a tangent to the curve at that point, and then find the gradient of the tangent.

A tangent is a line that is parallel to the curve at that point.

3) You can also calculate the average speed of an object when it has non-uniform motion (i.e. it's accelerating) by dividing the total distance travelled by the time it takes to travel that distance.

EXAMPLE:

The graph shows the distance/time graph for a cyclist on his bike.
Calculate:
a) the speed of the bike 25 s into the journey.
b) the average speed of the cyclist from 0 to 30 s.



a) Draw the tangent to the curve at 25 s (red line).
Then calculate the gradient of the tangent (blue lines).

$$\text{gradient} = \frac{\text{change in the vertical}}{\text{change in the horizontal}} = \frac{80}{10} = 8\text{ m/s}$$

b) Use the formula from page 12 to find the average speed of the bike.

average speed = distance ÷ time = 150 ÷ 30 = 5 m/s

Tangent — a man who's just come back from holiday...

For practice, try sketching distance/time graphs for different scenarios. Like walking home or running from a bear.

Q1 Sketch a distance/time graph for an object that initially accelerates, then travels at a constant speed, then decelerates to a stop. [2 marks]

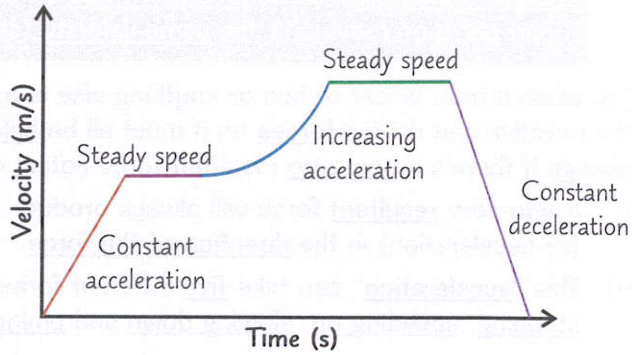
Velocity/Time Graphs

Huzzah, more graphs — velocity/time graphs this time. These look a lot like the distance/time graphs on page 14, so make sure you check the labels on the axes really carefully. You don't want to mix them up.

Velocity/Time Graphs can have a Positive or Negative Gradient

How an object's velocity changes over time can be plotted on a velocity/time (or v/t) graph.

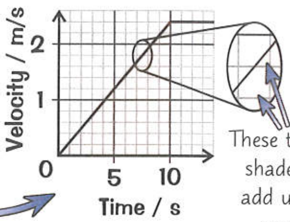
1) Gradient = acceleration, since acceleration = change in velocity ÷ time.
2) Flat sections represent a steady speed.
3) The steeper the graph, the greater the acceleration or deceleration.
4) Uphill sections (/) are acceleration.
5) Downhill sections (\) are deceleration.
6) A curve means changing acceleration.



If the graph is curved, you can use a tangent to the curve (p.14) at a point to find the acceleration at that point.

The Distance Travelled is the Area Under the Graph

1) The area under any section of the graph (or all of it) is equal to the distance travelled in that time interval.
2) For bits of the graph where the acceleration's constant, you can split the area into rectangles and triangles to work it out.
3) You can also find the area under the graph by counting the squares under the line and multiplying the number by the value of one square.



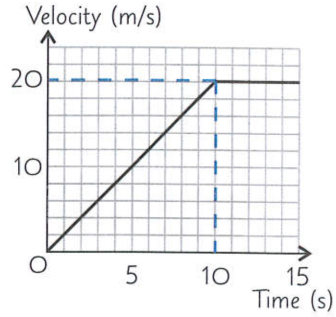
These two partially shaded squares add up to make one square.

EXAMPLE:

The velocity/time graph of a car's journey is plotted.

a) Calculate the acceleration of the car over the first 10 s.

b) How far does the car travel in the first 15 s of the journey?



a) This is just the gradient of the line:

$a = (v - u) \div t$
$= (20 - 0) \div 10 = 2\ \text{m/s}^2$

b) Split the area into a triangle and a rectangle, then add together their areas — remember the area of a triangle is ½ × base × height.

Area = (½ × 10 × 20) + (5 × 20)
= 200 m

Or find the value of one square, count the total number of squares under the line, and then multiply these two values together.

1 square = 2 m/s × 1 s = 2 m
Area = 100 squares
= 100 × 2 = 200 m

Understanding motion graphs — it can be a real uphill struggle...

Make sure you know the differences between distance/time and velocity/time graphs, and how to interpret them.

Q1 A stationary car starts accelerating increasingly for 10 s until it reaches a speed of 20 m/s. It travels at this speed for 20 s until the driver sees a hazard and brakes. He decelerates uniformly, coming to a stop 4 s after braking.

a) Draw the velocity/time graph for this journey. [3 marks]

b) Using the graph, calculate the deceleration of the car when it brakes. [2 marks]

Newton's First and Second Laws

In the 1660s, a chap called Isaac Newton worked out his dead useful Laws of Motion. Here are the first two.

A Force is Needed to Change Motion

This may seem simple, but it's important. Newton's First Law says that a resultant force (p.67) is needed to make something start moving, speed up or slow down:

> If the resultant force on a stationary object is zero, the object will remain stationary. If the resultant force on a moving object is zero, it'll just carry on moving at the same velocity (same speed and direction).

So, when a train or car or bus or anything else is moving at a constant velocity, the resistive and driving forces on it must all be balanced. The velocity will only change if there's a non-zero resultant force acting on the object.

1) A non-zero resultant force will always produce acceleration (or deceleration) in the direction of the force.
2) This "acceleration" can take five different forms: starting, stopping, speeding up, slowing down and changing direction.

Acceleration is Proportional to the Resultant Force

1) The larger the resultant force acting on an object, the more the object accelerates — the force and the acceleration are directly proportional. You can write this as $F \propto a$.
2) Acceleration is also inversely proportional to the mass of the object — so an object with a larger mass will accelerate less than one with a smaller mass (for a fixed resultant force).
3) There's an incredibly useful formula that describes Newton's Second Law:

$$F = m \times a$$

Resultant force (N) — Mass (kg) — Acceleration (m/s^2)

Large Decelerations can be Dangerous

1) Large decelerations of objects and people (e.g. in car crashes) can cause serious injuries. This is because a large deceleration requires a large force — $F = m \times a$.
2) The force can be lowered by slowing the object down over a longer time, i.e. decreasing its deceleration.
3) Safety features in vehicles are designed to increase collision times, which reduces the force, and so reduces the risk of injury. For example, seat belts stretch slightly and air bags slow you down gradually. Crumple zones are areas at the front and back of a vehicle which crumple up easily in a collision, increasing the time taken to stop.

EXAMPLE: Estimate the resultant force acting on a car stopping quickly from 15 m/s.

1) Estimate the deceleration of the car — you did that for this example on page 13.
   The car comes to a stop in ~1 s.
   $a = (v - u) \div t = (0 - 15) \div 1 = -15$ m/s^2
2) Estimate the mass of the car.
   Mass of a car is ~1000 kg.
3) Put these numbers into Newton's 2nd Law.
   $F = m \times a$
   $= 1000 \times -15 = -15\,000$ N

The force here is negative as it acts in the opposite direction to the motion of the car.

4) The brakes of a vehicle do work on its wheels (see p.66). This transfers energy from the vehicle's kinetic energy store to the thermal energy store of the brakes. Very large decelerations may cause the brakes to overheat (so they don't work as well). They could also cause the vehicle to skid.

Accelerate your learning — force yourself to revise...

Newton's First Law means that an object moving at a steady speed doesn't need a net force to keep moving.

Q1 Find the resultant force needed to accelerate an 80 kg man on a 10 kg bike at 0.25 m/s^2. [2 marks]

Weight and Circular Motion

Now for something a bit more attractive — the force of gravity. Enjoy...

Weight and Mass are Not the Same

1) Mass is just the amount of 'stuff' in an object. For any given object this will have the same value anywhere in the universe.
2) Mass is a scalar quantity. It's measured in kilograms with a mass balance (an old-fashioned pair of balancing scales).

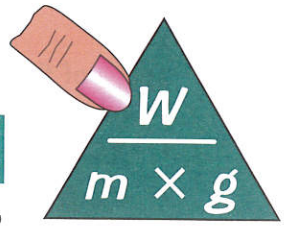
> Gravity attracts all masses, but you only notice it when one of the masses is really big (like a planet).

3) Weight is the force acting on an object due to gravity (the pull of the gravitational force on the object). Close to Earth, this force is caused by the gravitational field around the Earth.
4) Weight is a force measured in newtons. You can think of the force as acting from a single point on the object, called its centre of mass (a point at which you assume the whole mass is concentrated).
5) Weight is measured using a calibrated spring balance (or newton meter).

Weight Depends on Mass and Gravitational Field Strength

1) You can calculate the weight of an object if you know its mass (m) and the strength of the gravitational field that it is in (g):

Weight (N) = mass (kg) × gravitational field strength (N/kg)



2) Gravitational field strength varies with location. It's stronger the closer you are to the mass causing the field (and more massive objects create stronger fields).
3) This means that the weight of an object changes with its location.

EXAMPLE: What is the weight, in newtons, of a 2.0 kg chicken on Earth (g = 10 N/kg)?

Calculate the weight on Earth using the equation for weight given above.

$W = m \times g = 2.0 \times 10 = 20$ N

The chicken has a weight of 16 N on a mystery planet. What is the gravitational field strength of the planet?

1) Rearrange the weight equation for g.
2) Substitute the values in.

$g = W \div m$
$= 16 \div 2.0 = 8.0$ N/kg

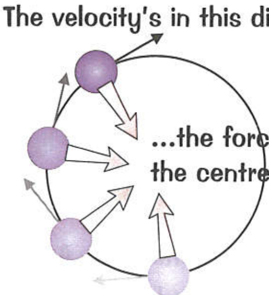
> Remember — the mass of the chicken is the same on every planet, it's the weight of the chicken that changes.

Circular Motion — Velocity is Constantly Changing

> See p.59 for more on gravity causing circular motion.

1) Velocity is both the speed and direction of an object (p.12).
2) If an object is travelling in a circle (at a constant speed) it is constantly changing direction, so it is constantly changing velocity. This means it's accelerating.
3) This means there must be a resultant force (p.67) acting on it.
4) This force acts towards the centre of the circle.
5) This force that keeps something moving in a circle is called a centripetal force.

> It's pronounced sen-tree-pee-tal.



I don't think you understand the gravity of this situation...

Remember that weight is a force due to gravity and that it changes depending on the strength of the gravitational field the object is in. Gravity can cause circular motion (in things like moons and satellites — see page 59).

Q1 Calculate the weight in newtons of a 25 kg mass:
a) on Earth ($g \approx 10$ N/kg) b) on the Moon ($g \approx 1.6$ N/kg) [4 marks]

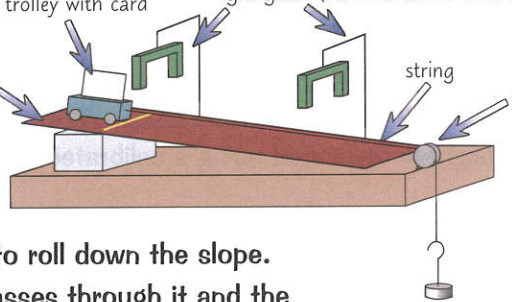
Investigating Motion

Doing an experiment for yourself can really help you to understand what's going on with $F = ma$ (p.16).

You can Investigate the Motion of a Trolley on a Ramp

PRACTICAL

1) Measure the mass of the trolley, the unit masses and the hanging hook. Measure the length of the piece of card which will interrupt the light gate beams. Then set up your apparatus as shown in the diagram below, but don't attach the string to the trolley.
2) Adjust the height of the ramp until the trolley just starts to move.
3) Mark a line on the ramp just before the first light gate — this is to make sure the trolley travels the same distance every time. The light gate will record the initial speed of the trolley as it begins to move.



4) Attach the trolley to the hanging mass by the string. Hold the trolley still at the start line, and then let go of it so that it starts to roll down the slope.
5) Each light gate will record the time when the trolley passes through it and the speed of the trolley at that time. The acceleration of the trolley can then be found using acceleration = change in speed ÷ time, with the following values:
   - the initial speed of the trolley as it passes through the first light gate (it'll be roughly 0 m/s),
   - the final speed of the trolley, which equals the speed of the trolley through the second light gate,
   - the time it takes the trolley to travel between the two light gates.

By changing the height of the ramp so that the trolley just begins to move, it means that any other forces that are applied (like the force due to gravity caused by the hanging mass) will be the main cause of the trolley accelerating as it travels down the ramp (page 16).
The size of this acceleration depends on the mass of the trolley and the size of the accelerating force.

- To investigate the effect of the trolley's mass: add masses one at a time to the trolley. Keep the mass on the hook constant (so the accelerating force is constant — where the force is equal to the mass on hook × acceleration due to gravity). Repeat steps 2-5 of the experiment above each time.
- To investigate the effect of the accelerating force: start with all the masses loaded onto the trolley and transfer the masses to the hook one at a time. Again, repeat steps 2-5 each time you move a mass.
  You transfer the masses because you need to keep the mass of the whole system (the mass of the trolley + the mass on the hook) the same. This is because the accelerating force causes BOTH the trolley and the hanging masses to accelerate.

You should find that as the accelerating force increases, the acceleration increases (for a given trolley mass). So force and acceleration are proportional. As the mass of the trolley increases its acceleration decreases (for a given force) — mass and acceleration are inversely proportional.

You can use Different Equipment to Measure Distance and Time

Light gates (p.106) are often the best option for short time intervals. They get rid of the human error caused by reaction times (p.22). But light gates aren't the only way to find the speed of an object:

1) For finding something like a person's walking speed, the distances and times you'll look at are quite large. You can use a rolling tape measure (one of those clicky wheel things) and markers to measure and mark out distances. And for any times longer than five seconds, you can use a regular stopwatch.
2) If you're feeling a bit high-tech, you could also record a video of the moving object and look at how far it travels each frame. If you know how many frames per second the camera records, you can find the distance travelled by the object in a given number of frames and the time that it takes to do so.

My acceleration increases with nearby cake...

Make sure you know multiple methods for measuring the speed (distance travelled in a time) of an object.

Q1 Why is it better to use a light gate instead of a stopwatch to measure short time intervals? [1 mark]

Inertia and Newton's Third Law

Inertia and Newton's Third Law can seem simple on the surface, but they can quickly get confusing. Make sure you really understand what's going on with them — especially if an object is in equilibrium.

Inertia is the Tendency for Motion to Remain Unchanged

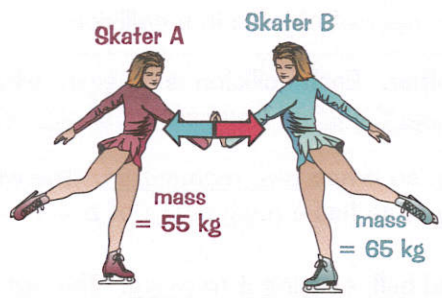
1) Until acted on by a resultant force, objects at rest stay at rest and objects moving at a constant velocity will stay moving at that velocity (Newton's First Law).
2) This tendency to keep moving with the same velocity is called inertia.
3) An object's inertial mass measures how difficult it is to change the velocity of an object.
4) Inertial mass can be found using Newton's Second Law of $F = ma$ (p.16). Rearranging this gives $m = F \div a$, so inertial mass is just the ratio of force over acceleration.

Newton's Third Law: Reaction Forces are Equal and Opposite

Newton's Third Law says:

> When two objects interact, the forces they exert on each other are equal and opposite.

1) If you push something, say a shopping trolley, the trolley will push back against you, just as hard.
2) And as soon as you stop pushing, so does the trolley. Kinda clever really.
3) So far, so good. The slightly tricky thing to get your head round is this — if the forces are always equal, how does anything ever go anywhere? The important thing to remember is that the two forces are acting on different objects.



When skater A pushes on skater B (the 'action' force), she feels an equal and opposite force from skater B's hand (the 'normal contact' force). Both skaters feel the same sized force, in opposite directions, and so accelerate away from each other.

Skater A will be accelerated more than skater B, though, because she has a smaller mass — remember $a = F \div m$.

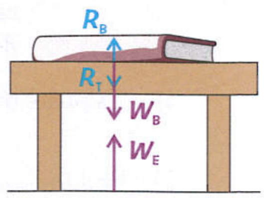
These equally-sized forces in opposite directions also explain the principle of conservation of momentum (see pages 20-21).

4) It's a bit more complicated for an object in equilibrium (p.68). Imagine a book sat on a table:

The weight of the book pulls it down, and the normal reaction force from the table pushes it up. These forces are equal to each other — the book is in equilibrium and doesn't move. This is NOT Newton's third law. These forces are different types and they're both acting on the book.

The pairs of forces due to Newton's third law in this case are:

- The book is pulled down by its weight due to gravity from Earth (W_B) and the book also pulls back up on the Earth (W_E).
- The normal contact force from the table pushing up on the book (R_B) and the normal contact force from the book pushing down on the table (R_T).



I have a reaction to forces — they bring me out in a rash...

Newton's 3rd law really trips people up, so make sure you understand exactly what objects the forces are acting on and how that results in movement (or lack of it). Then have a crack at this question to practise what you know.

Q1 A full shopping trolley and an empty one are moving at the same speed. Explain why it is easier to stop the empty trolley than the full trolley over the same amount of time. [1 mark]

Momentum

A large rugby player running very fast has much more momentum than a skinny one out for a Sunday afternoon stroll. It's something that all moving objects have, so you better get your head around it.

Momentum = Mass × Velocity

Momentum is a property that all moving objects have. (Think of it as how much 'oomph' something has.) It's defined as the product of the object's mass and velocity:

$$p = m \times v$$

momentum (kg m/s) = mass (kg) × velocity (m/s)

1) The greater the mass of an object, or the greater its velocity, the more momentum the object has.
2) Momentum is a vector quantity — it has size and direction.

EXAMPLE:

A 50 kg cheetah is running at 60 m/s. Calculate its momentum.

$p = m \times v = 50 \times 60$
$= 3000$ kg m/s

EXAMPLE:

A boy has a mass of 30 kg and a momentum of 75 kg m/s. Calculate his velocity.

$v = p \div m = 75 \div 30 = 2.5$ m/s

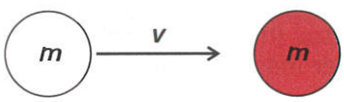
Total Momentum Before = Total Momentum After

A closed system is just a fancy way of saying that no external forces act.

In a closed system, the total momentum before an event (e.g. a collision) is the same as after the event. This is called conservation of momentum. You can use this to help you calculate things like the velocity or mass of objects in a collision.

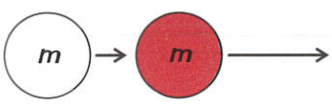
In snooker, balls of the same size and mass collide with each other. Each collision is an event where the momentum of each ball changes, but the overall momentum stays the same (momentum is conserved).

Before:



The red ball is stationary, so it has zero momentum. The white ball is moving with a velocity v, so has a momentum of $p = m \times v$.

After:



The white ball hits the red ball, causing it to move. The red ball now has momentum. The white ball continues moving, but at a much smaller velocity (and so a much smaller momentum).

The combined momentum of the red and white balls is equal to the original momentum of the white ball, $m \times v$.

EXAMPLE:

A 1500 kg car, travelling at 25 m/s, crashes into the back of a parked car. The parked car has a mass of 1000 kg. The two cars lock together and continue moving in the same direction as the original moving car. Calculate the velocity that the two cars move with.

1) Calculate the momentum before the collision. — $p = m \times v = 1500 \times 25 = 37\,500$ kg m/s
   Total momentum before = total momentum after
2) Find the combined mass of the cars. — New mass of joined cars = 2500 kg = M
3) Rearrange the equation to find the velocity of the cars. — $v = p \div M = 37\,500 \div 2500 = 15$ m/s

Learn this stuff — it'll only take a moment... um...

Conservation of momentum is incredibly handy — there's more on using it on the next page.

Q1 Calculate the momentum of a 60 kg woman running at 3 m/s. [2 marks]

Q2 Describe how momentum is conserved by a gun recoiling (moving backwards) as it shoots a bullet. [4 marks]

Changes in Momentum

A force causes the momentum of an object to change. A bigger force makes it change faster.

Forces Cause Changes in Momentum

1) When a resultant force acts on an object for a certain amount of time, it causes a change in momentum. Newton's 2nd Law can explain this:
   - A resultant force on an object causes it to accelerate: force = mass × acceleration (see p.16).
   - Acceleration is just change in velocity over time, so: force = $\frac{\text{mass} \times \text{change in velocity}}{\text{time}}$.
     This means a force applied to an object over any time interval will change the object's velocity.
   - Mass × change in velocity is equal to change in momentum, so you end up with the equation:

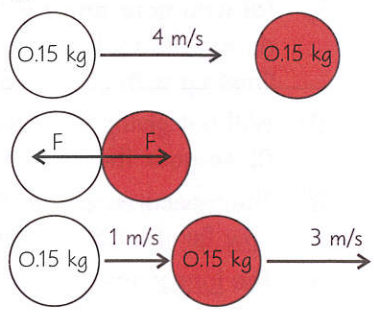
$$\text{force (N)} = \frac{\text{change in momentum (kg m/s)}}{\text{time (s)}} \quad \text{or} \quad F = \frac{(mv - mu)}{t}$$

2) The faster a given change in momentum happens, the bigger the force causing the change must be (i.e. if t gets smaller in the equation above, F gets bigger).
3) So if someone's momentum changes very quickly, like in a car crash, the forces on the body will be very large, and more likely to cause injury. There's more about this on p.16.
4) You can also think of changes in momentum in collisions in terms of acceleration — a change in momentum normally involves a change in velocity, which is what acceleration is (see p.13).
5) As you know, $F = ma$, so the larger the acceleration (or deceleration), the larger the force needed to produce it.

Conservation of Momentum Shows Newton's Third Law

The equation above can help to show Newton's Third Law (reaction forces are equal and opposite). Take the snooker balls from the previous page.

1) Before the collision, the white ball has a momentum of 0.15 × 4 = 0.6 kg m/s. The red ball has a momentum of zero.
2) The total momentum of the system is 0.6 kg m/s.
3) When the balls collide, the white ball exerts a force on the red ball. This force causes the red ball to start moving.
4) Due to Newton's 3rd Law, the red ball also exerts an equal but opposite force on the white ball. This force causes the white ball to slow down.
5) The collision lasts 0.1 s. After the collision, the white ball continues moving at 1 m/s. The red ball begins moving at 3 m/s.



6) The total momentum is (0.15 × 1) + (0.15 × 3) = 0.6 kg m/s. Momentum is conserved.
7) You can calculate the size of the force that caused this change of velocity (and so change of momentum) for each ball:
8) The force exerted on the white ball (by the red ball) is equal and opposite to the force exerted on the red ball (by the white ball). This shows Newton's Third Law.

white ball

$$F = \frac{(mv - mu)}{t} = \frac{(0.15 \times 1) - (0.15 \times 4)}{0.1} = \frac{-0.45}{0.1} = -4.5\ \text{N}$$

red ball

$$F = \frac{(mv - mu)}{t} = \frac{(0.15 \times 3) - (0.15 \times 0)}{0.1} = \frac{0.45}{0.1} = 4.5\ \text{N}$$

Homework this week — play pool to investigate momentum...

Sigh if only. Momentum is a pretty fundamental bit of physics — learn it well. Then have a go at this question.

Q1 Calculate the force a tennis racket needs to apply to a 58 g tennis ball to accelerate it from rest to 34 m/s in 11.6 ms. [3 marks]

Stopping Distances and Reaction Times

The stopping distance of a vehicle is the distance covered between the driver first spotting a hazard and the vehicle coming to a complete stop. It's made up of the thinking distance and the braking distance.

Stopping Distance = Thinking Distance + Braking Distance

The longer it takes a car to stop after seeing a hazard, the higher the risk of crashing. The distance it takes to stop a car (stopping distance) is divided into the thinking distance and the braking distance:

The thinking distance is the distance the car travels in the driver's reaction time (the time between noticing the hazard and applying the brakes). It's affected by two main factors:

1) Your reaction time — this is increased by tiredness, alcohol, drugs and distractions.
2) Your speed — the faster you're going, the further you'll travel during your reaction time.

The braking distance is the distance taken to stop once the brakes have been applied. It's affected by:

1) Your speed — the faster you're going, the longer it takes to stop (see next page).
2) The mass of the car — a car full of people and luggage won't stop as quickly as an empty car.
3) The condition of the brakes — worn or faulty brakes won't be able to brake with as much force.
4) How much friction is between your tyres and the road — you're more likely to skid if the road is dirty, if it's icy or wet or if the tyres are bald (tyres must have a minimum tread depth of 1.6 mm).

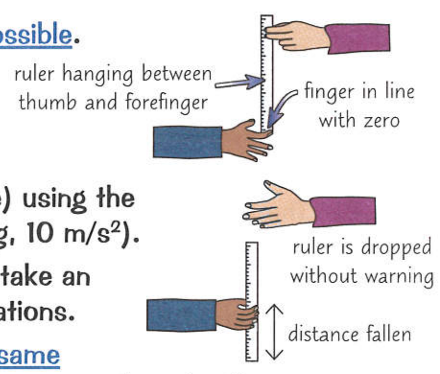
In the exam, you may need to spot the factors affecting thinking and braking distance in different situations. E.g. if a parent is driving her children to school early in the morning on an autumn day, her thinking distance could be affected by tiredness, or by her children distracting her. Her braking distance could be affected by ice, or by leaves on the road reducing the friction/grip.

The Ruler Drop Experiment Measures Reaction Times

Everyone's reaction time is different and many different factors affect it (see above).

One way of measuring reaction times is to use a computer-based test (e.g. clicking a mouse when the screen changes colour). Another is the ruler drop test:

1) Sit with your arm resting on the edge of a table (this should stop you moving your arm up or down during the test). Get someone else to hold a ruler so it hangs between your thumb and forefinger, lined up with zero. You may need a third person to be at eye level with the ruler to check it's lined up.
2) Without giving any warning, the person holding the ruler drops it. Close your thumb and finger to try to catch the ruler as quickly as possible.



3) The measurement on the ruler at the point where it was caught is how far the ruler dropped in the time it took you to react.
4) The longer the distance, the longer the reaction time.
5) You can calculate how long the ruler was falling for (the reaction time) using the equations on p.13 because its acceleration is constant (and equal to g, 10 m/s^2).
6) It's hard to do this experiment accurately, so do a lot of repeats and take an average of the distance the ruler fell. Use this average in your calculations.
7) Make sure it's a fair test — keep the variables you aren't testing the same every time, e.g. use the same ruler for each repeat and have the same person dropping it.
8) For an experiment like this, a typical reaction time is around 0.2-0.6 s.
9) A person's reaction time in a real situation (e.g. when driving) will be longer than that, though. Typically, an alert driver will have a reaction time of about 1 s.

Stop right there — and learn this page...

Bad visibility also causes accidents — if it's foggy, it's harder to notice a hazard, so there's less room to stop.

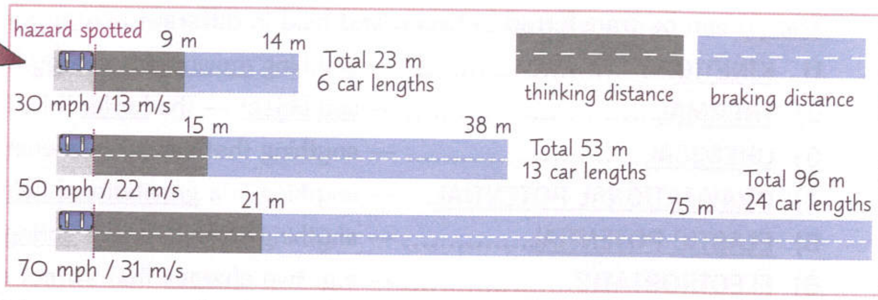
Q1 Drivers on long journeys should take regular breaks. Explain why, in terms of stopping distance. [3 marks]

Stopping Safely

So now you know what affects a car's stopping distance, let's have a look at the facts and figures.

Drivers Need to Leave Enough Space to Stop

1) These typical stopping distances are from the Highway Code.
2) To avoid an accident, drivers must leave enough space in front so they could stop safely — at least equal to the stopping distance for their speed.
3) Speed limits are really important because speed affects stopping distances so much. (Remember, weather and road conditions can affect them too.)
4) As speed increases, thinking distance increases at the same rate. This is because the driver's reaction time stays fairly constant, but the higher the speed, the further you go in that time ($d = st$, p.12).
5) However, braking distance and speed have a squared relationship — if speed doubles, braking distance increases by a factor of 4 (2^2), and if speed trebles, braking distance increases by a factor of 9 (3^2).



The brakes of a car do work on the car's wheels (see page 66). This transfers energy from the car's kinetic energy store to the thermal energy store of the brakes.

To stop a car, the brakes must transfer all of this energy, so:

There's more on these equations on pages 24 and 65.

Energy in the car's kinetic energy store = Work done by the brakes

$$\tfrac{1}{2} \times m \times v^2 = F \times d$$

m — mass of the car; v — speed of car; F — braking force; d — braking distance

This means doubling the mass doubles the braking distance.

You can Estimate the Distances Involved in Stopping

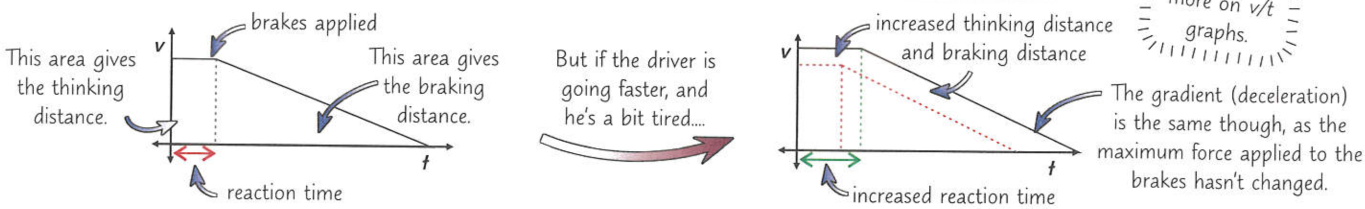
EXAMPLE: A car travelling at 25 m/s makes an emergency stop to avoid a hazard. The braking force applied to the car is 5000 N. Estimate the total distance taken to stop.

1) Estimate the driver's reaction time.
   Reaction time is ~1 s.
2) Calculate the thinking distance.
   $d = v \times t = 25 \times 1 = 25$ m
3) To work out the braking distance, rearrange the equation above for d, and estimate the mass of the car.
   $d = (\tfrac{1}{2} \times m \times v^2) \div F$
   Mass of a car is ~1000 kg
   $d = (\tfrac{1}{2} \times 1000 \times 25^2) \div 5000$
   $= 62.5$ m
4) Add the thinking distance and braking distance to give the stopping distance.
   $25 + 62.5 = 87.5$ m Distance is ~90 m

Make sure you can estimate the mass of objects. A car's mass is ~1000 kg. A single decker bus is ~10 000 kg and a loaded lorry is ~30 000 kg.

Thinking and Braking Distance can be Seen on v/t Graphs

See p.15 for more on v/t graphs.



It's enough to put you off learning to drive, isn't it...

This is quite a tough page, but it's important, so head back to the top and read it again.

Q1 Estimate the size of the force needed to stop a lorry travelling at 16 m/s within 50 m. [4 marks]

Energy Stores

Energy stores are different ways of storing energy. Simple really...

Energy is Transferred Between Energy Stores

Energy can be transferred between and held in different energy stores. There are eight you need to know:

1) KINETIC............................ — anything moving has energy in its kinetic energy store (see below).
2) THERMAL........................... — any object — the hotter it is, the more energy it has in this store.
3) CHEMICAL.......................... — anything that can release energy by a chemical reaction, e.g. food, fuels.
4) GRAVITATIONAL POTENTIAL... — anything in a gravitational field (i.e. anything that can fall) (see below).
5) ELASTIC POTENTIAL............. — anything stretched, like springs, rubber bands, etc. (p.100).
6) ELECTROSTATIC.................. — e.g. two charges that attract or repel each other.
7) MAGNETIC.......................... — e.g. two magnets that attract or repel each other.
8) NUCLEAR........................... — atomic nuclei release energy from this store in nuclear reactions.

A Moving Object has Energy in its Kinetic Energy Store

1) When an object is moving, it has energy in its kinetic energy store.
2) Energy is transferred to this store if an object speeds up and away from this store if it slows down.
3) How much energy is in this store depends on both the object's mass and its speed.
4) The greater its mass and the faster it's going, the more energy it has in its kinetic energy store.
5) For example, a high-speed train will have a lot more energy in its kinetic energy store than you running.
6) You can find the energy in a kinetic energy store using:

$$\underset{(J)}{\text{kinetic energy}} = 0.5 \times \underset{(kg)}{\text{mass}} \times \underset{(m/s)^2}{(\text{speed})^2} \quad \text{or} \quad KE = \tfrac{1}{2} \times m \times v^2$$

7) If you double the mass, the energy in the kinetic energy store doubles. If you double the speed, though, the energy in the kinetic energy store quadruples (increases by a factor of 4) — it's because of the '(speed)^2' in the formula.

EXAMPLE: A car of mass 1450 kg is travelling at 28 m/s. Calculate the energy in its kinetic energy store, giving your answer to 2 s.f.

kinetic energy = 0.5 × mass × (speed)^2
= 0.5 × 1450 × 28^2 = 568 400 = 570 000 J (to 2 s.f.)

Watch out for the (speed)^2 — that's where people tend to make mistakes and lose marks.

An Object at a Height has Energy in its Gravitational Potential Energy Store

1) When an object is at any height above the Earth's surface, it will have energy in its gravitational potential energy store.
2) You can calculate the change in energy in the gravitational potential energy store using the equation:

$$\Delta GPE = m \times g \times \Delta h$$

Change in gravitational potential energy (J); Mass (kg); Gravitational field strength (N/kg); Change in vertical height (m)

Δ just means 'change in'.

There's potential for a joke here somewhere...

Hopefully this page wasn't too hard — just don't forget that squared sign when you're working and remember that the energy in an object's kinetic energy store only changes if its speed is changing. Now have a crack at this...

Q1 A 2 kg object is dropped from a height of 10 m. Calculate the speed of the object after it has fallen 5 m, assuming there is no air resistance. g = 10 N/kg. [5 marks]

Transferring Energy

Now you know about the different energy stores, it's time to find out how energy is transferred between them.

Conservation of Energy Means Energy is Never Created or Destroyed

Energy can be stored, transferred between stores, and dissipated — but it can never be created or destroyed. The total energy of a closed system has no net change.

See the next page for more on dissipation.

A closed system is just a system (a collection of objects) that can be treated completely on its own and where there is no net change in the system's total energy. If you get a question where the energy of a system increases or decreases, then it's not closed. But you can make it into a closed system by increasing the number of things you treat as part of it. E.g. a pan of water heating on a hob isn't a closed system, but the pan, the gas and the oxygen that burn to heat it, and their surroundings are a closed system.

Energy Transfers Show... well... the Transfer of Energy

Energy can be transferred between stores in four main ways:

1) Mechanically — a force acting on an object (and doing work, p.66), e.g. pushing, stretching, squashing.
2) Electrically — a charge doing work (p.72), e.g. charges moving round a circuit.
3) By heating — energy transferred from a hotter object to a colder object, e.g. heating a pan on a hob.
4) By radiation — energy transferred by waves, e.g. energy from the Sun reaching Earth by light.

Make sure you understand what's going on in these examples of energy transfers:

A BALL ROLLING UP A SLOPE:
The ball does work against the gravitational force, so energy is transferred mechanically from the kinetic energy store of the ball to its gravitational potential energy store.

A BAT HITTING A BALL:
The bat has energy in its kinetic energy store. Some of this is transferred mechanically to the ball's kinetic energy store. Some energy is also transferred mechanically to the thermal energy stores of the bat and the ball (and to the surroundings by heating). The rest is carried away by sound.

A ROCK DROPPED FROM A CLIFF:
Assuming there's no air resistance, gravity does work on the rock, so the rock constantly accelerates towards the ground. Energy is transferred mechanically from the rock's gravitational potential energy store to its kinetic energy store.

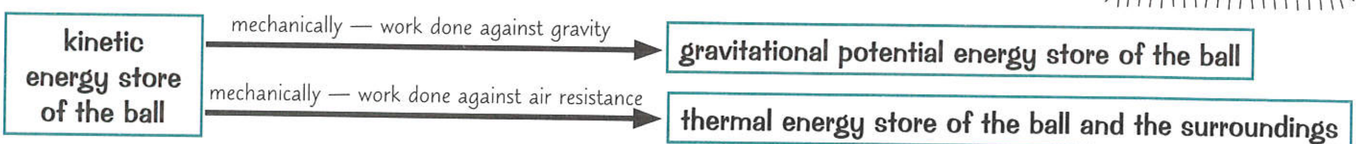
A CAR SLOWING DOWN (without braking):
Energy in the kinetic energy store of the car is transferred mechanically (due to friction between the tyres and road), and then by heating, to the thermal energy stores of the car and road.

A KETTLE BOILING WATER:
Energy is transferred electrically from the mains to the heating element of the kettle, and then by heating to the thermal energy store of the water.

You can Draw Diagrams to Show Energy Transfers

Diagrams can make it easier to see what's going on when energy is transferred. The diagram below shows the energy transferred when a ball is thrown upwards, taking air resistance into account. The boxes represent stores and the arrows show transfers:

You may have to use or draw a diagram like this in the exam, so make sure you understand what it's showing.



Energy can't be created or destroyed — only talked about a lot...

This is important, so remember it. Energy can only be transferred to a different store, never destroyed.

Q1 Describe the energy transfers that occur when a piece of wood is burning. [2 marks]

Efficiency

So energy is transferred between different stores. But not all of the energy is transferred to useful stores.

Most Energy Transfers Involve Some Losses, Often by Heating

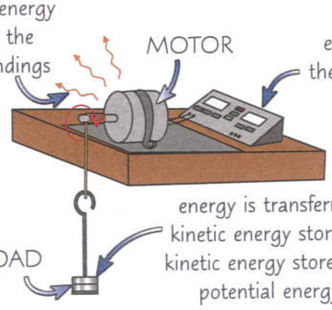
1) You've already met the principle of conservation of energy on the previous page, but another important principle you need to know is:

Energy is only useful when it is transferred from one store to a useful store.

Dissipated is a fancy way of saying the energy is spread out and so is 'lost'.

2) Useful devices can transfer energy from one store to a useful store.
3) However, some of the input energy is always dissipated or wasted, often to thermal energy stores of the surroundings.
4) Whenever work is done mechanically (see p.25), frictional forces have to be overcome, including things like moving parts rubbing together, and air resistance. The energy needed to overcome these frictional forces is transferred to the thermal energy stores of whatever's doing the work and the surroundings.
5) This energy usually isn't useful, and is quickly dissipated.

The diagram shows a motor lifting a load.
The motor transfers energy usefully from its kinetic energy store to the kinetic energy store and the gravitational potential energy store of the load, but it also transfers energy mechanically to the thermal energy stores of its moving parts, and electrically to the thermal energy stores of its circuits.
This energy is dissipated, heating the surroundings.



6) The conservation of energy principle means that:
total energy input = useful energy output + wasted energy.
7) The less energy that's wasted, the more efficient the device is said to be.
The amount of energy that's wasted can often be reduced — see next page.

You can Calculate the Efficiency of an Energy Transfer

The efficiency of any device is defined as:

$$\text{efficiency} = \frac{\text{useful energy transferred by device (J)}}{\text{total energy supplied to device (J)}}$$

This will give the efficiency as a decimal. To give it as a percentage, you need to multiply the answer by 100.

EXAMPLE: A toaster transfers 216 000 J of energy electrically from the mains. 84 000 J of energy is transferred to the bread's thermal energy store. Calculate the efficiency of the toaster.

$$\text{efficiency} = \frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}} = \frac{84\,000}{216\,000} = 0.388... = 0.39 \text{ (to 2 s.f.)}$$

This could also be written as 39% (to 2 s.f.).

All devices have an efficiency, but because some energy is always wasted, the efficiency can never be equal to or higher than 1 (or 100%).

Make sure your revising efficiency is high...

One really important thing to take from here — devices that transfer energy from one store to other stores will always transfer energy to stores that aren't useful. And when I say always, I mean always. Always. (Always.)

Q1 An electrical device wastes 420 J of energy when it has an input energy of 500 J.
Calculate the efficiency of the device as a percentage. [3 marks]

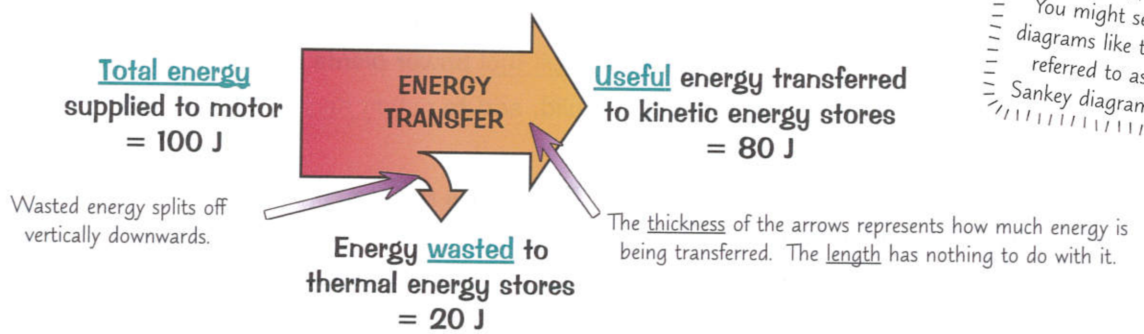
Reducing Unwanted Energy Transfers

There are many ways you can reduce the amount of energy that is wasted during a process (and so increase its efficiency) — lubrication and thermal insulation are two of the main ones that you need to know about.

You can Use Diagrams to Show Efficiency

No device is 100% efficient (see previous page), but some are more efficient than others. You can use diagrams like the one below to show the different energy transfers made by a device, and so how efficient it is:

Diagram for an electric motor with 80% efficiency:



You might see diagrams like this referred to as Sankey diagrams.

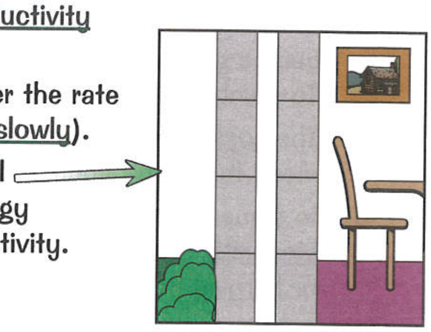
You can reduce the amount of energy that's wasted in various ways — including by lubrication and by thermal insulation. Decreasing the amount of wasted energy means that a higher proportion of the supplied energy is transferred to useful stores, so the efficiency of the process is increased.

Lubrication Reduces Energy Transferred by Friction

1) Whenever something moves, there's usually at least one frictional force acting against it.
2) This transfers energy mechanically (work is done against friction) to the thermal energy store of the objects involved, which is then dissipated by heating to the surroundings. For example, pushing a box along the ground causes energy to be transferred mechanically to the thermal energy stores of the box and the ground. This energy is then radiated away to the thermal energy store of the surroundings.
3) For objects that are touching each other, lubricants can be used to reduce the friction between the objects' surfaces when they move. Lubricants are usually liquids (like oil), so they can flow easily between objects and coat them.

Insulation Reduces the Rate of Energy Transfer by Heating

1) When one side of an object is heated, the particles in the hotter part vibrate more and collide with each other. This transfers energy from their kinetic energy stores to other particles, which then vibrate faster.
2) This process is called conduction. It transfers energy through the object.
3) All materials have a thermal conductivity — it describes how well a material transfers energy by conduction. For example, metals have a high thermal conductivity and gases (like air) have a low thermal conductivity.
4) In a building, the lower the thermal conductivity of its walls, the slower the rate of energy transfer through them (meaning the building will cool more slowly).
5) Some houses have cavity walls, made up of an inner and an outer wall with an air gap in the middle. The air gap reduces the amount of energy transferred by conduction, because air has a very low thermal conductivity.
6) Thicker walls help too — the thicker the wall, the slower the rate of energy transfer.



Don't waste energy — turn the TV off while you revise...

Unwanted energy transfers can cost you a lot in energy bills — it's why so many people invest in home insulation.

Q1 Suggest one way to improve the efficiency of an electric motor. [1 mark]

Energy Resources

There are lots of energy resources available on Earth. They are either renewable or non-renewable resources.

Non-Renewable Energy Resources Will Run Out One Day

Non-renewable energy resources are fossil fuels and nuclear fuel (uranium and plutonium). They currently provide most of the world's energy. Fossil fuels are natural resources that form underground over millions of years that are typically burnt to provide energy. The three main fossil fuels are coal, oil and (natural) gas.

1) Fossil fuels and nuclear energy are RELIABLE. There's still plenty of fuel around to meet current demand, and power plants always have fuel in stock. This means they can respond quickly to changes in energy demand — they use more fuel to release more energy.
2) The cost to extract fossil fuels is low and fossil fuel power plants are relatively cheap to build and run.
3) Nuclear power plants are pretty costly to build, and to safely decommission.
4) Fossil fuels are slowly running out.
5) They create ENVIRONMENTAL PROBLEMS. Fossil fuels release carbon dioxide (CO_2) into the atmosphere when they're burned, which adds to the greenhouse effect, and contributes to global warming.
6) Burning coal and oil can also release sulfur dioxide, which causes acid rain. Acid rain can be reduced by taking the sulfur out before the fuel is burned, or cleaning up the emissions.
7) Oil spillages cause serious environmental problems, affecting mammals and birds that live in and around the sea. We try to avoid them, but they'll always happen.
8) Nuclear power is clean but the nuclear waste is very dangerous and difficult to dispose of. And there's always the risk of a major catastrophe like the Fukushima disaster in Japan.

Renewable Energy Resources Will Never Run Out

Renewable energy resources include:

1) Bio-fuels
2) Wind
3) The Sun (solar)
4) Hydro-electricity
5) Tides

- These will never run out — the energy can be 'renewed' as it is used.
- Most of them do damage the environment, but in less nasty ways than non-renewables.
- The trouble is they don't provide much energy and some of them are unreliable because they depend on the weather.

Bio-fuels are Made from Plants and Waste

1) Bio-fuels are renewable energy resources created from either plant products or animal dung. They can be solid, liquid or gas and can be burnt to produce electricity or run cars in the same way as fossil fuels.
2) They are supposedly carbon neutral, although there is some debate about this as it's only really true if you keep growing plants (or raising animals) at the rate that you're burning things.
3) Bio-fuels are fairly reliable, as crops take a relatively short time to grow and different crops can be grown all year round. However, they cannot respond to immediate energy demands. To combat this, bio-fuels are continuously produced and stored for when they are needed.
4) The cost to refine bio-fuels is very high and some worry that growing crops specifically for bio-fuels will mean there isn't enough space or water to meet the demands for crops that are grown for food.
5) In some regions, large areas of forest have been cleared to make room to grow bio-fuels, resulting in lots of species losing their natural habitats. The decay or burning of this cleared vegetation also increases methane and CO_2 emissions.

Burning poo... lovely...

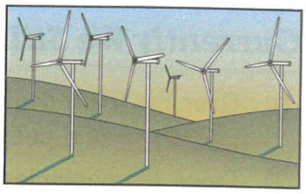
Given our electricity-guzzling ways, it's pretty important we find ways to generate electricity without destroying the planet. Burning cow pats may not be the ultimate fix, but it's a start. See the next page for more ways.

Q1 State two renewable energy sources. [2 marks]

More Energy Resources

Renewable energy resources, like wind, solar, hydro-electricity and tides, won't run out. They don't generate as much electricity as non-renewables though — if they did we'd all be using solar-powered toasters by now.

Wind Power — Lots of Little Wind Turbines



1) Each wind turbine has a generator inside it — wind rotates the blades, which turn the generator and produce electricity. So there's no pollution.
2) Initial costs are quite high, but running costs are minimal.
3) But lots of them are needed to produce as much power as, for example, a coal power plant. This means they can spoil the view. They can also be noisy, which can be annoying for people living nearby.
4) They only work when it's windy, so you can't always supply electricity, or respond to high demand.

Solar Cells — Expensive but No Environmental Damage

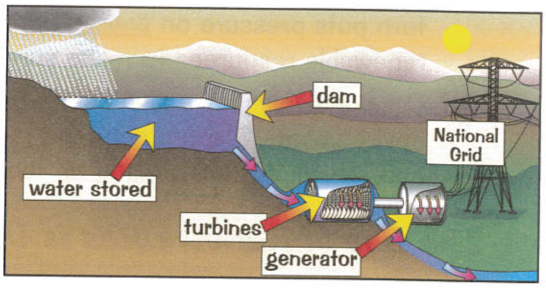
There's some pollution when the energy resources on this page are made, but not when they're in use.

1) Solar cells are made from materials that use energy transferred by light to create an electric current.
2) Solar power is often used in remote places where there's not much choice (e.g. the Australian outback) and to power electric road signs and satellites.
3) There's no pollution. (Although they do use quite a lot of energy to make.)
4) Initial costs are high, but there are basically no running costs.
5) They're mainly used to generate electricity on a relatively small scale, e.g. in homes.
6) Solar power is most suitable for sunny countries, but it can be used in cloudy countries like Britain.
7) And of course, you can't make solar power at night or increase production when there's extra demand.

Time to recharge.

Hydro-electricity — Building Dams and Flooding Valleys

1) Producing hydro-electricity usually involves flooding a valley by building a big dam. Rainwater is caught and allowed out through turbines. There is no pollution (as such).
2) There is a big impact on the environment due to the flooding of the valley and possible loss of habitat for some species.
3) A big advantage is it can immediately respond to increased electricity demand — more water can be let out through the turbines to generate more electricity.



4) Initial costs are often high but there are minimal running costs and it's generally a reliable energy source.

Tidal Barrages — Using the Sun and Moon's Gravity

1) Tidal barrages are big dams built across river estuaries with turbines in them.
2) As the tide comes in it fills up the estuary. The water is then let out through turbines at a controlled speed to generate electricity.
3) There is no pollution but they affect boat access, can spoil the view and they alter the habitat for wildlife, e.g. wading birds.
4) Tides are pretty reliable (they always happen twice a day). But the height of the tides is variable and barrages don't work when the water level is the same either side.
5) Initial costs are moderately high, but there are no fuel costs and minimal running costs.

The hydro-electric power you're supplying — it's electrifying...

There are pros and cons to all energy resources. Make sure you know them for solar, wind and water.

Q1 The government is considering closing down a traditional coal-fired power station. Explain the benefits and disadvantages of replacing the power station with a wind farm. [4 marks]

Trends in Energy Resource Use

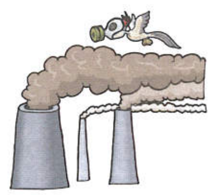
Over time, the types of energy resources we use change. There are lots of reasons for this — breakthroughs in technology, understanding more about how they affect the environment or changes in cost are just a few.

Currently We Still Depend on Fossil Fuels

1) Over the 20th century, the electricity use of the UK hugely increased as the population got bigger and people began to use electricity for more and more things.
2) Since the beginning of the 21st century, electricity use in the UK has been decreasing (slowly), as we get better at making appliances more efficient (p.26) and try to be more careful with energy use in our homes.
3) Most of our electricity is produced using fossil fuels (mostly coal and gas) and from nuclear power. But we do use renewable energy resources like wind power to generate some of our electricity.
4) Generating electricity isn't the only reason we burn fossil fuels — oil (diesel and petrol) is used to fuel cars, and gas is used to heat homes and cook food.
5) However, renewable energy resources can be used for these purposes as well. Bio-fuels can be used to exclusively power vehicles, and solar water heaters can be used to heat buildings.
6) We are trying to increase our use of renewable energy resources (the UK aims to use renewable resources to provide 15% of its total yearly energy by 2020). This move towards renewable energy resources has been triggered by many things...

Energy Resources are Chosen for their Effect on the Environment

1) We now know that burning fossil fuels has a lot of negative effects on the environment (p.28). This has led to many people wanting to use more renewable energy resources that have less of an effect on the environment.
2) Pressure from other countries and the public has meant that governments have begun to introduce targets for using renewable resources. This in turn puts pressure on energy providers to build new power plants that use renewable resources to make sure they do not lose business and money.
3) Car companies have also been affected by this change in attitude towards the environment. Electric cars and hybrids (cars powered by two fuels, e.g. petrol and electricity) are already on the market and their popularity is increasing.



The Use of Renewables is Usually Limited by Reliability and Money

1) Building new renewable power plants costs money, so some smaller energy providers are reluctant to do this — especially when fossil fuels are such a cost effective way of meeting demand.
2) Even if new power plants are built, there are a lot of arguments over where they should be. E.g. many people don't want to live next to a wind farm, which can lead to protests.
3) Some energy resources like wind power are not as reliable as traditional fossil fuels, whilst others cannot increase their power output on demand. This would mean either having to use a combination of different power plants (which would be expensive) or researching ways to improve reliability.
4) Research into improving the reliability and cost of renewable resources takes time and money. This means that, even with funding, it might be years before improvements are made. In the meantime, dependable, non-renewable power stations have to be used.
5) Making personal changes can also be quite expensive. Hybrid cars are generally more expensive than equivalent petrol cars and things like solar panels for your home are still quite pricey. The cost of these things is slowly going down, but they are still not an option for many people.

Going green is on-trend this season...

So with more people wanting to help the environment, others not wanting to be inconvenienced and greener alternatives being expensive to set up, the energy resources we use are changing. Just not particularly quickly.

Q1 Give two reasons we currently do not use more renewable energy resources in the UK. [2 marks]

Revision Questions for Section 1

Wow, that was a whole lot of Physics in one place — time to see how much of it you can remember.

- Try these questions and tick off each one when you get it right.
- When you've done all the questions under a heading and are completely happy, tick it off.

Motion (p.12-15) ☐

1) What is the difference between a scalar and a vector quantity? Give two examples of each. ☐
2) Give the equation relating distance, speed and time. ☐
3) Estimate typical speeds for a) walking, b) running, c) a car in a built-up area. ☐
4) Define acceleration in terms of velocity and time. ☐
5) What does the gradient represent for a) a distance/time graph? b) a velocity/time graph? ☐
6) How would you find the distance travelled by an object from its velocity/time graph? ☐

Newton's Laws, Forces and Momentum (p.16-21) ☐

7) State Newton's First and Second Laws of Motion. ☐
8) Explain why cars have safety features to reduce the decelerations experienced by passengers. ☐
9) What is the formula for calculating the weight of an object? ☐
10) Explain why there must be a force acting to produce circular motion. What is the name of the force? ☐
11) Describe an experiment to investigate Newton's Second Law of Motion. ☐
12) What is inertia? ☐
13) What is Newton's Third Law of Motion? Give an example of it in action. ☐
14) State the formula used to calculate an object's momentum. ☐
15) Explain the link between Newton's Third Law and conservation of momentum. ☐

Car Safety (p.22-23) ☐

16) What is meant by a person's reaction time? Describe an experiment to measure reaction time. ☐
17) State two factors that can affect the thinking distance for a stopping car. ☐
18) State four things that can affect the braking distance of a vehicle. ☐

Energy Stores, Transfers and Efficiency (p.24-27) ☐

19) What is the equation for calculating the energy in a moving object's kinetic energy store? ☐
20) State the conservation of energy principle. ☐
21) What is meant by the 'dissipation' of energy? ☐
22) Describe the energy transfers when a ball is rolled up a slope. ☐
23) Describe the energy transfers when a hair dryer is switched on. ☐
24) Give the equation for the efficiency of a device. ☐
25) How can you reduce unwanted energy transfers in a machine with moving, touching components? ☐
26) How does the thermal conductivity of a wall affect its rate of energy transfer? ☐

Energy Resources and Trends in their Use (p.28-30) ☐

27) What is the difference between renewable and non-renewable energy resources? ☐
28) What are bio-fuels made from? Explain the benefits and drawbacks of using bio-fuels. ☐
29) Give two benefits and two disadvantages of solar and wind power. ☐
30) Explain why the UK plans to use more renewable energy resources in the future. ☐