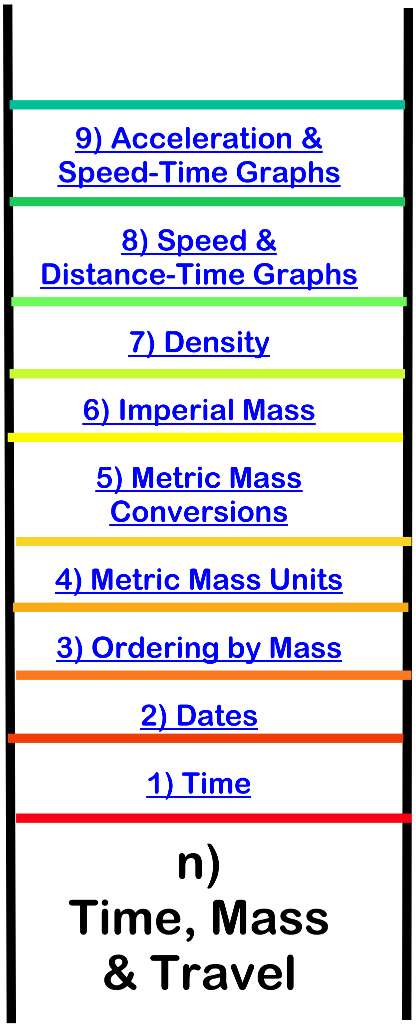
n) Time, Mass & Travel

1 2 3 4 5 6 7 8 9

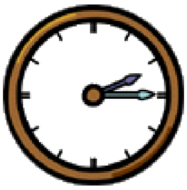


Step 1) Time

Quite amazingly, the planet Earth that we live on, is spinning all the time. That is why we get night and day. For some of its spin the bit we are on faces the sun (light day times) and for some of the time the bit we are on face away from the sun (dark night times). We call the total time to go through a whole dark and light cycle of spinning a day.

We break the day up into 24 equal parts and call them hours. This gives us some idea about what part of the day we are in. A clock has 12 numbers around it, and two spins around the clock face takes 24 hours, in other words a whole day. On a clock the short hand represents what hour it is.

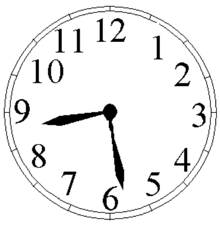
We see this on the clock in the evening. Here the big hand is between the 9th and 10th hour. The long hand tells us how far around the hour we are. It does one spin each hour, and as it is half way round, we know it is half past nine, or 9.30pm. The pm means between midday and midnight, in other words afternoon or evening.



This clock shows the time half way through our night's sleep. Here the hour hand is just past 2, and the minute hand is quarter of the way around the whole hour, so it is quarter past two or 2.15am (am means between midnight and midday, the sleepiest part of the night and the morning).

This is the time in the morning we might wake up. And here the hour hand is coming up for 8, and you can see the minute hand is three quarters of the way around, in other words a quarter before 8 o'clock, so we call it quarter to 8, or 7.45am

The minute hand can be used much more precisely than halves and quarters. There are 60 little dashes around the clock face and each one represents one minute, or 1/60th of an hour.



Here the hour hand is between 8 and 9 in the evening, but the minute hand is only 1 minute before half past. This is 29 minutes past 8, or 8.29pm

This explains why half past nine was 9.30 (as 30 mins is half of a full hour, half of 60 minutes) and quarter past 2 was 2.15 (as 15 minutes is a quarter of 60 mins or an hour).

Similarly a minute can be split in to 60 equal parts, called seconds.

60 seconds = 1 minute

60 minutes = 1 hour

24 hours = 1 day

One very important other piece of information is that sometimes we write times in a 24 hour clock format. So after midday we get

1 o'clock = 13 hours

2 o'clock = 14 hours and so on.

When you bring in the minutes, the morning times are almost the same except you might need a zero..

7.45am = 07:45 hours

But pm times have an extra 12 hours…

8.29pm = 20:29 hours

Let's look at half past each hour in 12 and 24 hour clocks.

12 hour clock	24 hour clock
12.30am	00:30
1.30am	01:30
2.30am	02:30
3.30am	03:30
4.30am	04:30
5.30am	05:30
6.30am	06:30
7.30am	07:30
8.30am	08:30
9.30am	09:30
10.30am	10:30
11.30am	11:30
12.30pm	12:30
1.3pm	13:30
2.3pm	14:30
3.30pm	15:30
4.30pm	16:30
5.30pm	17:30
6.30pm	18:30
7.30pm	19:30
8.30pm	20:30
9.30pm	21:30
10.30pm	22:30
11.30pm	23:30

Step 2) Dates

Dates are also a measure of time. They deal with times when we have more than one day.

We group 7 days together and call this a week, and give each day a name. Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday. These days are all named after different things. Monday is named after the moon, and Sunday is named after the sun. Can you guess what the others days are named after (chips on a Friday anyone, ha ha).

You may notice that over time, the days can be longer or shorter, and in general hotter (when they are longer) or colder (when they are shorter) too. This happens as our planet earth travels around the sun. It takes about 365¼ days for this to happen. So we use a 365 day a year calender, then every four years we have an extra day to make up for the quarter days. We call this 366 day year a leap year.

We divide the year up into 12 months, that have between 28 and 31 days. A month is named after the moon, though the months on a calendar don't match the moon very closely (they are usually a bit longer than a moon cycle which goes from full moon to full moon in about 28 days, or 4 lots of the 7-day week).

Amazingly there used to be only ten months, but Julius Caesar and Augustus Caesar back in Roman times, decided to name an extra month after themselves, so we got July and August. This also explains why the month named after the number Oct-ober is actually the 10th month. And the month named after the number 10, dec-ember, is actually the 12th month. The months September, October, November and December were given their names based on there month numbers, back when there were only 10 months in pre-roman times. Confusing eh! Blame the arrogant roman emperors for that one.

The full list of months in order are

Name	Calendar Month Number	Digital Calendar Number
January	1	01
February	2	02
March	3	03
April	4	04
May	5	05
June	6	06
July	7	07
August	8	08
September	9	09
October	10	10
November	11	11
December	12	12

I (the author of this book) was born on the 17th day in January.

I was also born 1978 years after Jesus Christ's official birth year. The Western calendar always counts years after Jesus's birthday. This is because of the romans again, they took Christianty around the world, and with it a calendar based on Jesus birthday. So my birthday is written 17/01/1978.17th day, of the first month (January) 1978 years after Jesus' birth.

Somewhat confusingly, Jesus birth is celebrated on 25th December, not 1st Jan, which is when calendar years are counted from.

The ancient past is measured in years BC, which means Before Christ.

Step 3) Ordering by Mass

Mass is a measure of how much of something there is, but rather than measuring how big it is (called volume) it measures how hard it is to lift it up. Something with a large mass, is heavy, it is hard to pick up (like a house). Something with a small mass is light, it is easy to pick up, like an apple.

If you live on Earth's surface, weight is almost the same as mass. But weight is connected to gravity, which relies on you staying on the same planet. In short mass is the same on earth, or on the moon (the physical amount of stuff remains the same), but your weight is not the same on the moon, as the moon is small and so has a lot less gravity (about 1/6 of the Earths). So you weight 6 times less on the moon, but you mass the same. Don't worry if you don't understand this paragraph, unless you are planning to travel into space.

The reason mass is different to volume, is that you can get the same amount of something and make it larger (like boiling water into a gas, it gets bigger), by simply spreading out the atoms or particles. Mass actually measures how many sub-atomic particles there are, the total number of protons and neutrons gives you the mass (we often ignore electrons as they are so light compared to protons and neutrons).

Okay, enough crazy (but important) concepts. Let's put this into practice…

Put the following items in order of mass from smallest mass (lightest) to largest mass (heaviest) an elephant, a carrot, a dictionary, a jumbo jet, a feather.

Well the phrase as light as a feather is there for a reason, though there are things lighter than feathers, but not on this list…

lightest: feather

2nd: carrot

3rd: dictionary

4th : an elephant

heaviest: a jumbo jet

Step 4) Metric Mass Units

The metric mass units are grams, kilograms and tonnes.

1,000 grams = kilogram

1,000 kilograms = tonne

The reason we use grams (g) and kilograms (kg) instead of the number of protons and neutrons is that there are 33,300,000,000,000,000,000,000 protons and neutrons in a gram. That is 333 with 20 zeros! Or 333 with 23 zeros in a kg, or 333 with 26 zeros in a tonne. So we use g and kg to shorten the number of zeros when we find the mass of things.

Let's think about how we might use them.

What units would you use to measure the mass of a plate of food, a person, or a ship.

Well a plate of food would be the lightest and we would measure this in grams.

A person would be measured in kg (though in the UK we still use stones, an imperial, or old measure of mass, explained in the next step).

A ship would be measured in tonnes as it is very, very heavy.

To think about this another way: a single apple would probably be measured in grams (g); a box of apples would be measured in kilograms (kg); a whole lorry of boxes of apples would be measured in tonnes.

An estimate for the mass of a bowl of food ≈ 237g, a person ≈ 83kg, and a ship ≈ 58,000 tonnes

Step 5) Metric Mass Conversions

Although we prefer to measure in a unit that gives us a sensible number, you can convert between any mass units.

Remember that

1,000 grams (g) = kilogram (kg)

1,000 kilograms = tonne (t

So to convert between grams and kg, we need to divide by 1,000 (or x 1,000 to go the other way)

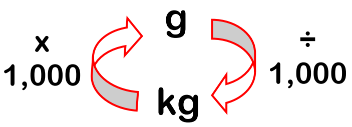
To convert between kg and tonnes again we must divide by 1,000 (or x 1,000 to go the other way)

To convert between grams and tonnes we have to times or divide by a million (1,000,000) as there are 1,000 x 1,000 grams in a tonne (1,000 in each kg).

	Plate of Food	Person	Ship
g	237 g	83,000 g	58,000,000,000 g
kg	0.237 kg	83kg	58,000,000k g
t	0.000237 t	0.083 t	58,000 t

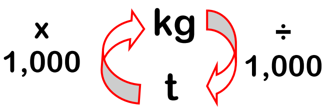
We can summerise these conversions using a conversion cycle. Showing our two units, and in which direction we x, and which we ÷ by our conversion rate. Let's look at these and use them.

How many grams are there in 2.37 kg?



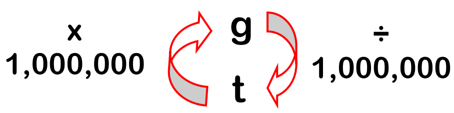
2.37 x 1,000 = 2,370 grams

How many tonnes is 72,500 kg?



72,500 ÷ 1,000 = 72.5 t

How many grams are there in 92 tonnes?



92 x 1,000,000 = 92,000,000 g (92 million grams).

This last question shows us why the different units are useful. If we always have to measure in millions (or millionths) we have to use a lot for zeros. With these different units we can measure in smaller, simpler numbers, for different types of things using the most suitable unit.

Step 6) Imperial Mass

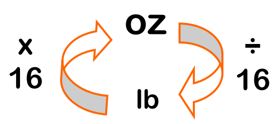
Imperial measures are the older measures that were used before everything went decimal in the UK. Decimal systems are where all the units use powers of ten like 10, 100 and 1,000 to convert between things. Before that there were different numbers for all different types of conversions. Imperial mass measurements are called ounces (oz) pounds (lb) which are not to be confused with the money measure of pounds (£) and tons (this is said the same, and has the same symbol – t – but is different mass to a metric tonne).

16 ounces = 1 pound

2240 pounds = 1 ton

(not to be confused with 1 tonne)

How many pounds is 56 ounces?

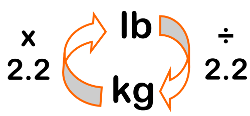


56 ÷ 16 = 3.5 lbs (or 3½ pounds)

Because the imperial units have conversion rates that vary greatly, they don't fit that neatly into metric measurements either. Metric measurements are only simple when converted to other metric measurements. But never-the-less sometimes we need to convert between metric and imperial measurements of mass. Here is an example.

1 kg ≈ 2.2lbs

How many pounds is 7 kg of potatoes.



7 x 2.2 = 15.4 lbs of potatoes

Step 7) Density

Density is about how much mass you have in a given volume of space. So if you fit a few clothes for a weekend into a giant wheelie suitcase, there's a lot of space in there, the clothes would not be very densely packed, they'd have a low density. But if you squeezed those same clothes into a tiny day-rucksack they would be very densely packed in, they'd have a high density.

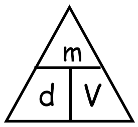
The volume you are fitting your mass into, makes a huge difference to how densely you have to pack the stuff in to that space. For this reason it is essential you can do and understand everything up to step 8 (volume of a cuboid) from ladder j (size) and preferably everything up to step 12 (volume of a prism), before learning about density, as it uses both volume and mass.

We work out the mass in a particular unit of volume, by dividing a larger volume's mass, by that volume.

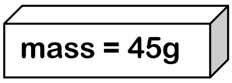
This works because dividing a given volume by itself gives a volume of 1 unit³, so we then know the mass within 1 unit³. This is similar to the unitary method that starts ladder g (on proportionality).

So density is the mass in a given unit³ and $density = \frac{mass}{volume}$ or $d = \frac{m}{V}$ for short.

We can also write this in a multiplication triangle.



This cuboid has volume 9cm³ and mass 45g. What is its density?



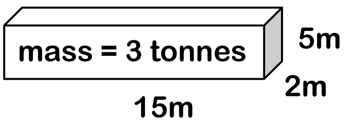
$$density = \frac{mass}{volume} = \frac{45}{9} = 5\, {}^{g}/_{cm^3}$$

In other words, as it takes 45g of stuff to fill 9cm³ of space, there must be 5g of stuff in each 1cm³ of space (as 5 x 9 = 45).

We have given the density in g/cm³, because this is the units the question was given in, but it is a standard unit of density. The other standard unit is kg/m³

We can find the density of objects where the volume isn't given but can be calculated.

Find the Density of this cuboid per kg/m³



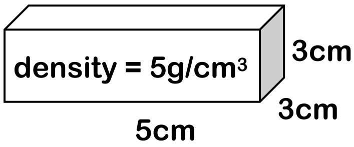
Volume = 5 x 2 x 15 = 150m³

3 tonnes = 3,000kg

$$d = \frac{m}{V} = \frac{3,000}{150} = 20kg/m^3$$

We can do all sorts of clever things with this relationship. For example if we know the density, and can find the volume, we can find the mass.

Find the mass of



Volume = 5 x 3 x 3 = 45cm³

Now $density = \frac{mass}{volume}$

and if we multiply both sides of this equation by volume (v) we find that

$$mass = density\ x\ volume$$

We can think about this as the density tells you the mass of 1 unit³ of volume, and you simply multiply this by the number of unit³ you have to find the total mass.

$$mass = 5\ \times 45 = 225g$$

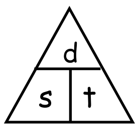
Step 8) Speed and Distance-Time Graphs.

Speed is a measure of how much time it takes to travel a certain distance. It doesn't matter which direction you travel, it is just how far you go. Velocity is like speed but it is a vector, which means the direction matters. If you run in a circle back to the start, you would have a positive speed, but your velocity would be 0.

Speed units tell us how far we travel in a given unit of time. For example metres per second… how many metres we travel in one second. Km/h is how many kilometres we travel in an hour.

The formula can be thought of like density, but instead of how many grams backed into a given volume, we have how much movement we pack into a given amount of time. So we take the total movement or distance travelled (in any direction) and divide it by the time taken, which gives us distance in one unit of time.

$speed = \frac{distance}{time}$ or $s = \frac{d}{t}$ or



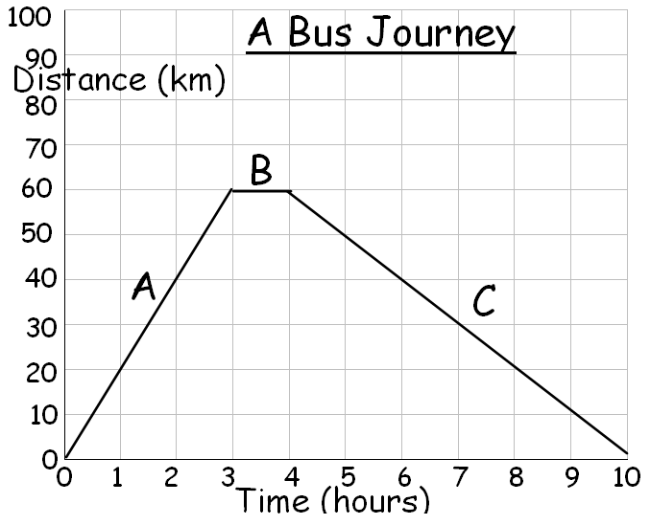
Find the speed when moving 300km in 5 hours

$$speed = \frac{distance}{time} = \frac{300}{5} = 60km/h$$

To reverse this, if we travel at 60km in every hour, for 5 hours, in total we will have travelled 5 x 60 = 300km (as the question says).

A distance time graph is a way of representing travelled distance over time in a visual and graphical way. It can be used to find speed too.

Here is an example of a distance (on the y-axis) time (on the x-axis) graph.



You can see 3 separate parts of the graph, one uphill (with positive gradient), one horizontal (with zero gradient), and one downhill (with negative gradient). We have labelled these A, B & C.

In part A of this journey, the bus moves for 3 hours, from a distance (from the starting point at 0 hours) 0km to a distance 60km, which means it has moved 60km. If a bus moves 60km in 3 hours, it has travelled at $\frac{60}{3} = 20$km/h. Because the line is straight we know it has moved at a constant speed. If the line was wiggly, we could describe 20km/h as the average speed in section A, but it moves at a constant speed as a straight line implies the same no of km per hour in each moment of that part of the journey.

In section B, the bus doesn't move at all for a whole hour. It starts section B at 60km from the start, and ends section B at 60km from the start, without moving. Could this be a break for the driver? Maybe it was lunch time! Either way, the speed of the bus is 0, as it has moved 0 km, in 1 hour. A horizontal line on a distance time graph always means the object is stationary, in other words not moving at all.

In section C the bus moves from 60km from the journey's start point, to 0km. So it travels 60km, again at constant speed as the line is straight. However this part of the journey takes 6 hours. So the speed of the bus in section C is $\frac{60}{6}$ = 10km/h.

We mentioned the gradient earlier. In fact the gradient of a speed time graph almost gives its speed. However you must remember that speed doesn't mind which direction you are going, so you can't have a negative speed (but you can have a negative velocity). This means that the gradient of section C is -6, but the speed is 6km/h not -6km/h.

This is a bit like using Pythagoras on a triangle and discovering that the length of the side is $\sqrt{25} = \pm 5$. But we ignore the -5, because the length of a line can't be negative, we don't mind in which direction we count the cm along the side, just how many cm there are.

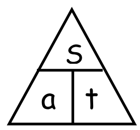
Step 9) Acceleration and Speed-Time Graphs

If we are standing still our speed is 0. To get to the point where we are moving we have to increase our speed to be above 0. How quickly our speed changes is called acceleration. In a car the right hand pedal is called the accelerator pedal, it is the one that changes the speed of the car (or gets it moving if it is stationary and has speed 0).

A sprinter starts off with speed 0 and tries to get to top running speed a quickly as possible. They aim to have as big an acceleration as possible. If you are walking to the local shop and not in any rush, you might get off the sofa very slowly and only reach your top walking speed halfway down the road, your acceleration is low.

The acceleration units involve a given unit of speed and a given unit of time. It tells you how many units of speed you change by, in a given unit of time. eg m/s/s or m/s^2

$acceleartion = \frac{speed}{time}$ or $a = \frac{s}{t}$ or



Find the acceleration when speed increases by 20m/s in 4s

$$acceleration = \frac{speed}{time} = \frac{20}{4} = 5m/s^2$$

Speed-time graphs are a visual way of displaying how the speed changes over time (and can be used to find acceleration).

This speed time graph represents the flight of a rocket. The speed is given on the y-axis, and the time on the x-axis.

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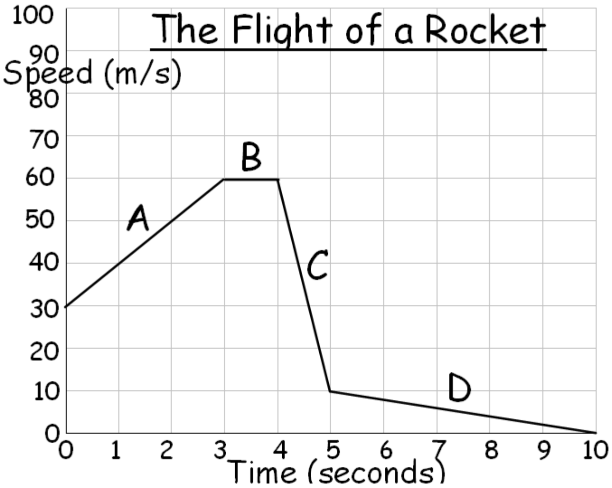

There are four clear sections of the graph, we have labelled them A, B, C and D.

In section A the speed goes from $30ms^{-1}$ to $60ms^{-1}$ taking 3 seconds to reach the higher speed. This means a change in speed of $30ms^{-1}$ in 3 seconds. Hence the acceleration is $\frac{30}{3} = 3ms^{-1}$ in this section of the rockets flight. It is a straight line so the change in speed is constant throughout (rather $3ms^{-1}$ being an average acceleration).

In section B the speed does not change. This means the acceleration is 0. A horizontal line on a speed time graph always represents an acceleration of 0, otherwise known as constant speed.

In section C the speed reduces from $60ms^{-1}$ to $10ms^{-1}$ over 1 second. This is a change in speed of 50ms-1 in 1 second. This clearly means a change in speed of $50ms^{-1}$ per second. In other words an acceleration of $50ms^{-2}$. Or with the formula acceleration $\frac{50}{1} = 50ms^{-2}$.

Finally in section D this fast deceleration slows to a change from $10ms^{-1}$ to $0ms^{-1}$, that is a change of $10ms^{-1}$ over 5 seconds. So the acceleration is $\frac{10}{5} = 2ms^{-2}$