Using Bar-Model to Solve Quantitative Science Problems

A pack of examples

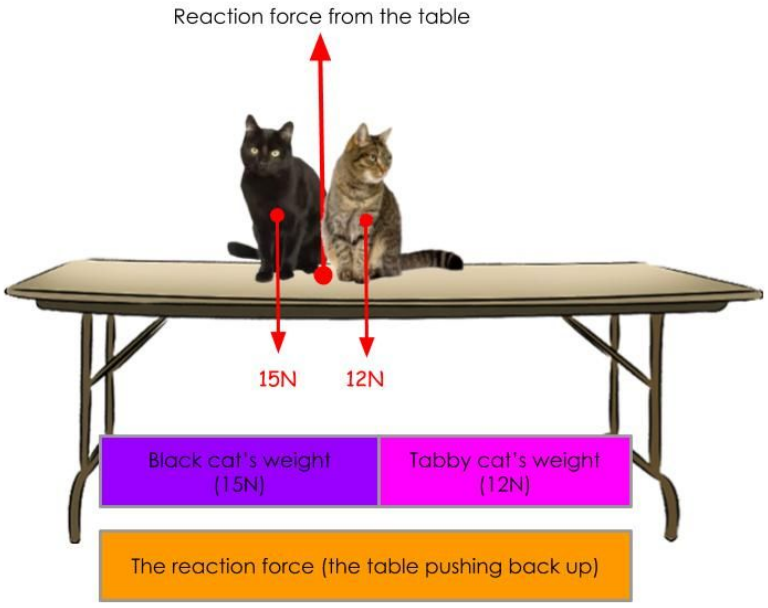
Introduction

The laws of Nature are written in the language of mathematics.

Galileo in The Assayer

To understand the science, you have to solve the problems. Key Stage 2 and 3 pupils are often more skilled at solving numerical problems in mathematics than science teachers realise.

This booklet uses a strategy commonly taught to primary pupils to solve quantitative science problems - the bar-model.



Bar model representing forces

Ben Rogers

Why Use Bar-Model?

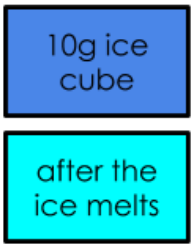
The bar-model is well known among primary maths teachers for helping pupils develop their maths problem solving skills. It originated in Singapore as part of their maths revolution over the past 20 years.

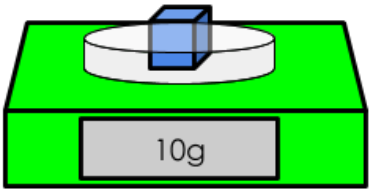
With thanks to With thanks to Jonathan Wragg, Lyndsay Sawyer, Ryan Doney and Anand Chauhan of Paradigm Trust for their knowledge, support and enthusiasm for this project

Problems

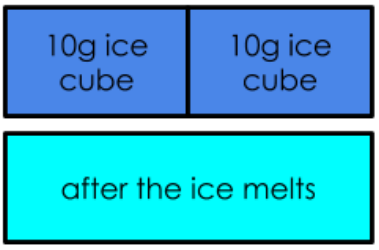
Conservation of Mass

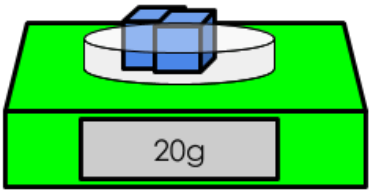
A 10g ice cube melts. What mass of water will it turn into?



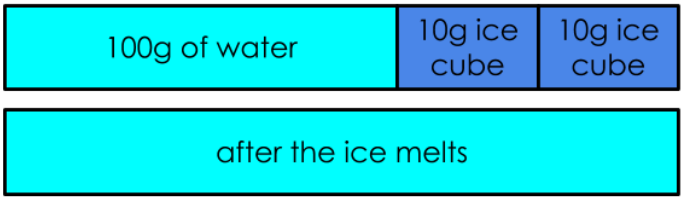


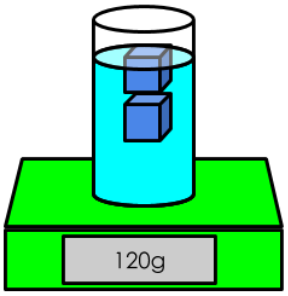
Two 10g ice cube melt. What mass of water will they turn into?



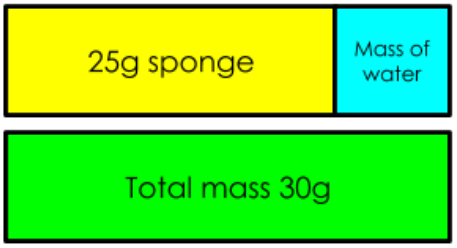


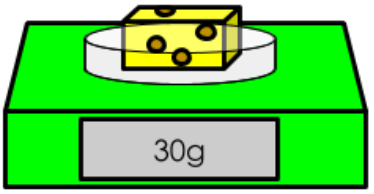
Two 10g ice cubes are added to 100g of water. After the ice cubes melt, what mass of water will there be?



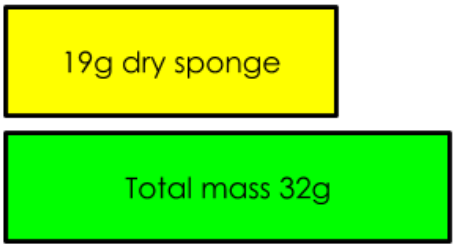


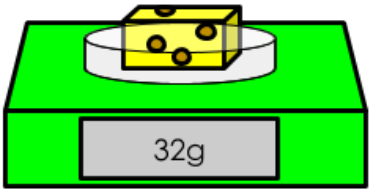
A dry sponge has a mass of 25g. When it is wet, it weighs 30g. What mass of water has it absorbed?





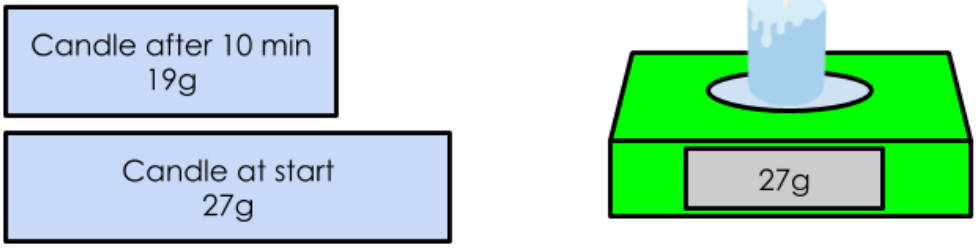
A wet sponge has a mass of 32g. After the water has evaporated, the mass of the sponge is 19g. How much water did the wet sponge contain?





A 27g candle burns for 10 minutes. After 10 minutes, its mass is 19g. How much wax has burned?

(stretch question - where has the extra mass gone?)

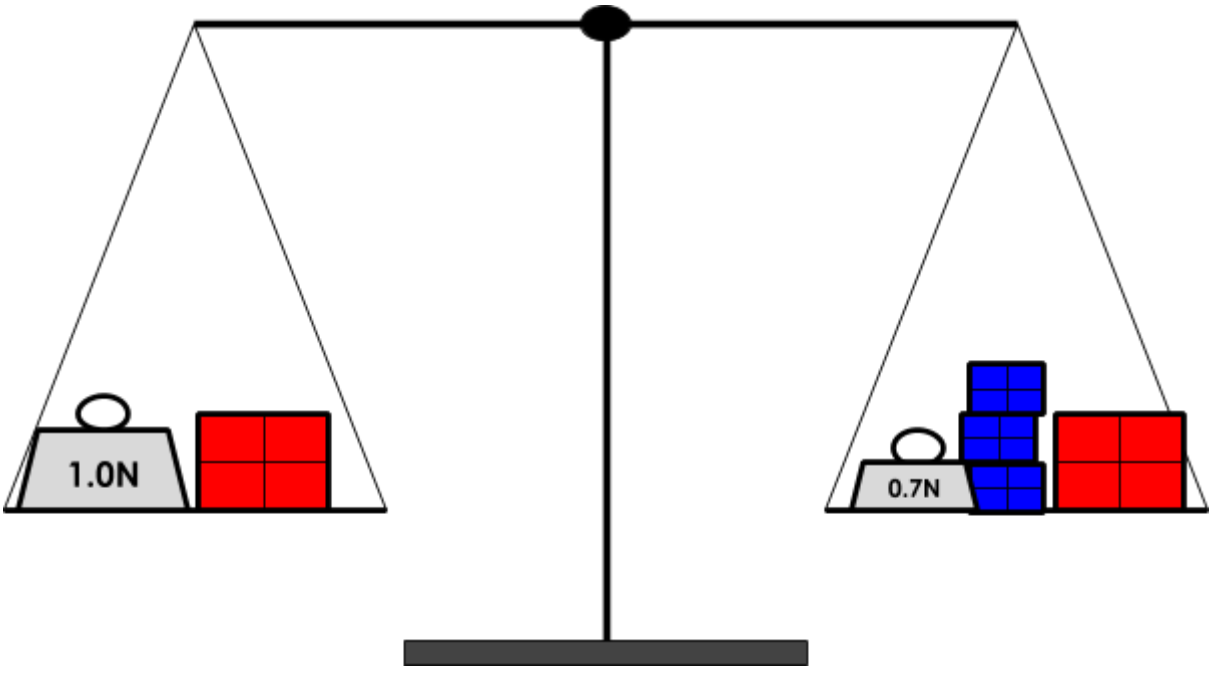


How-Much-Does-One-Weigh? Questions

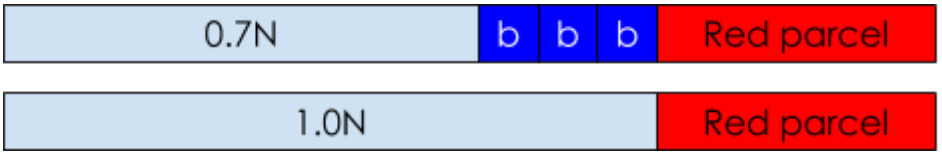
Adapted from the SATs reasoning question.

I do

Calculate the weight of each small blue parcel.



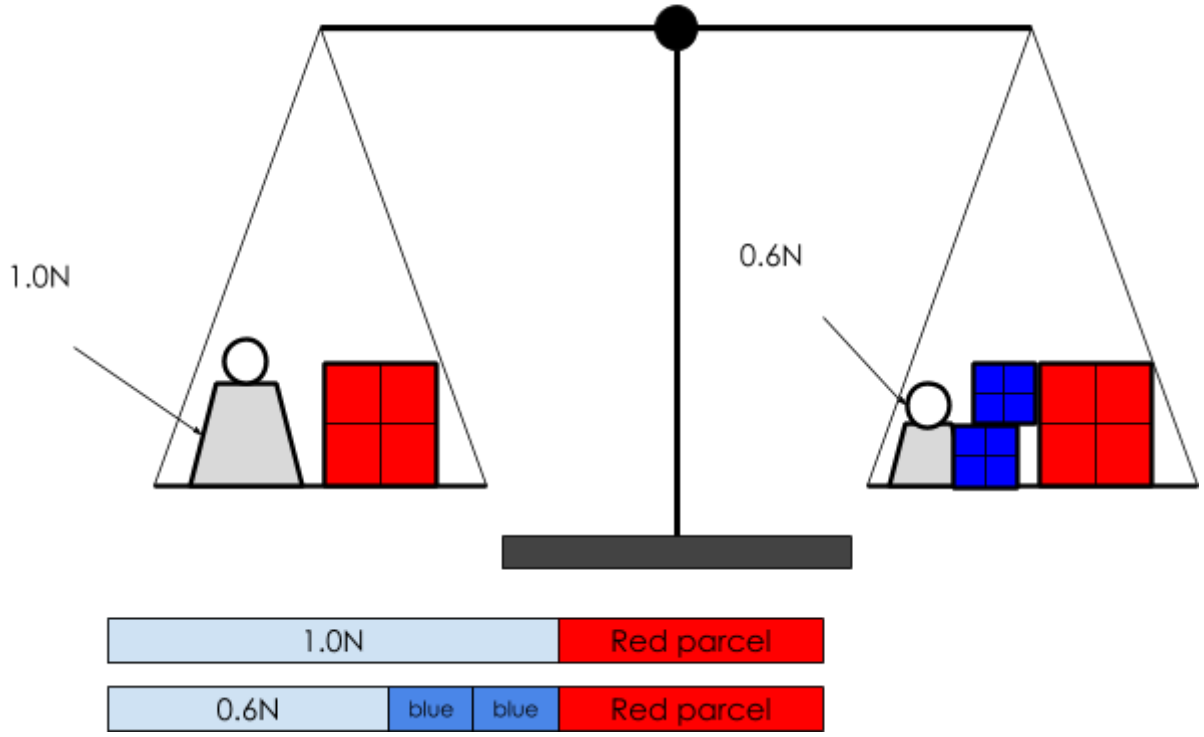
Solution, using bar model.



1.0N is the same as 0.7N and the three blue parcels.
So the three blue parcels added together must weigh 1.0 - 0.7 = 0.3N
So a single blue parcel must weight 0.3 divided by 3 = 0.1N

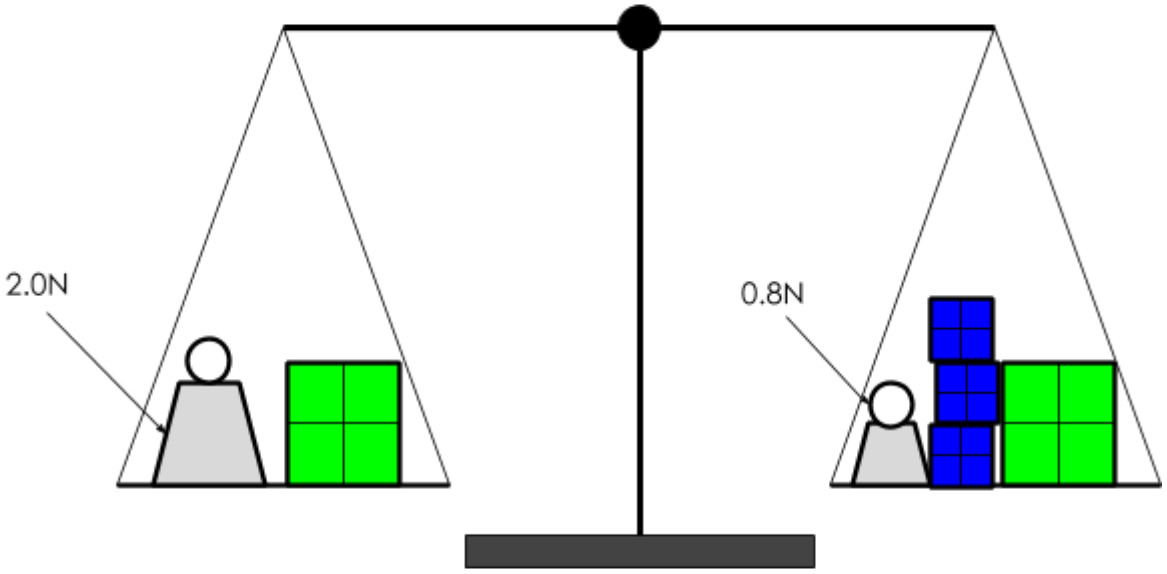
We do

Calculate the weight of one blue parcel.



You do

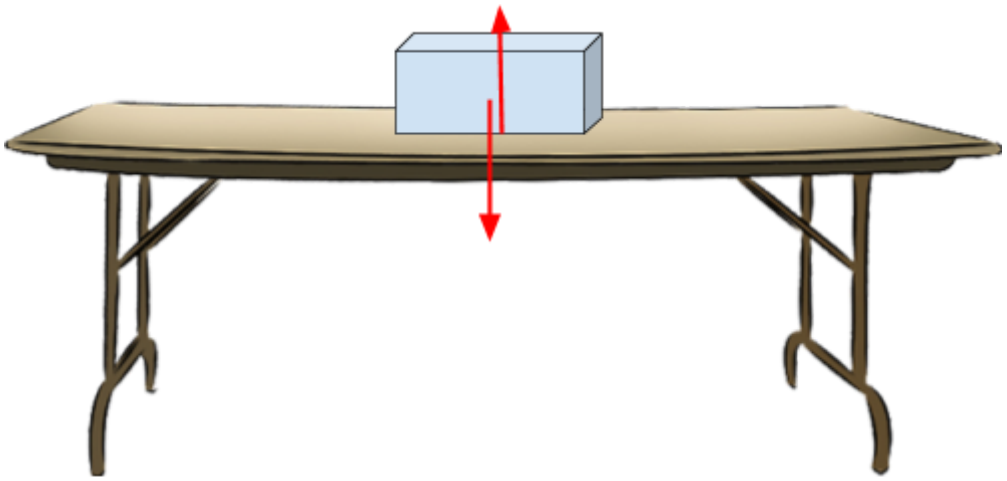
Calculate the weight of one blue parcel.



2.0N				Green parcel
0.8N	blue	blue	blue	Green parcel

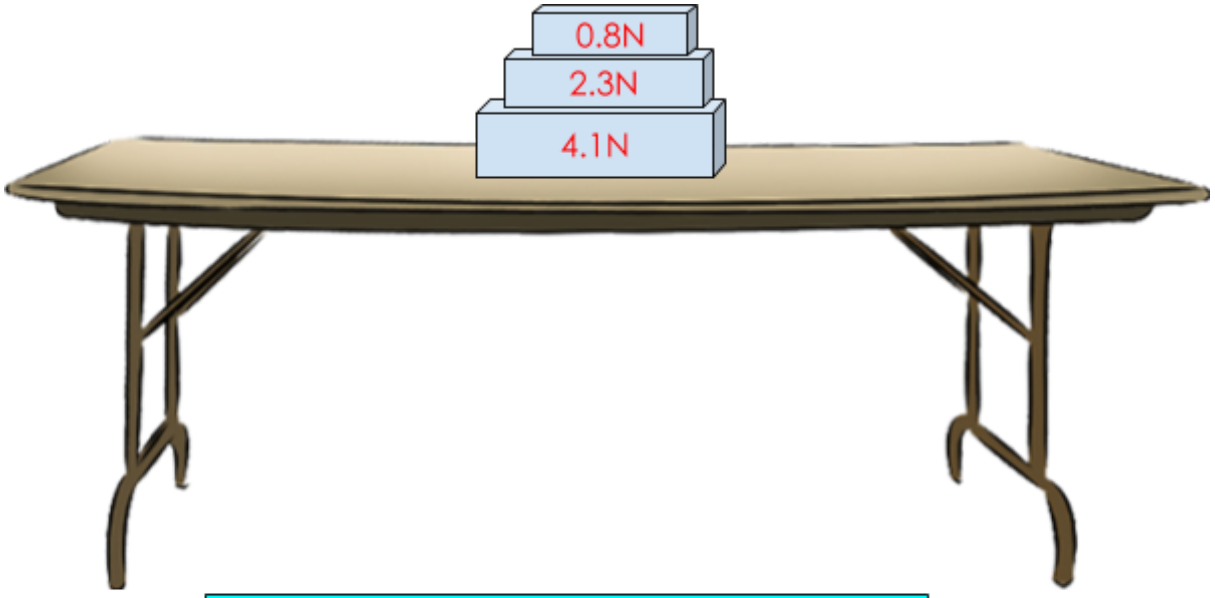
Balanced Forces

Reaction Force



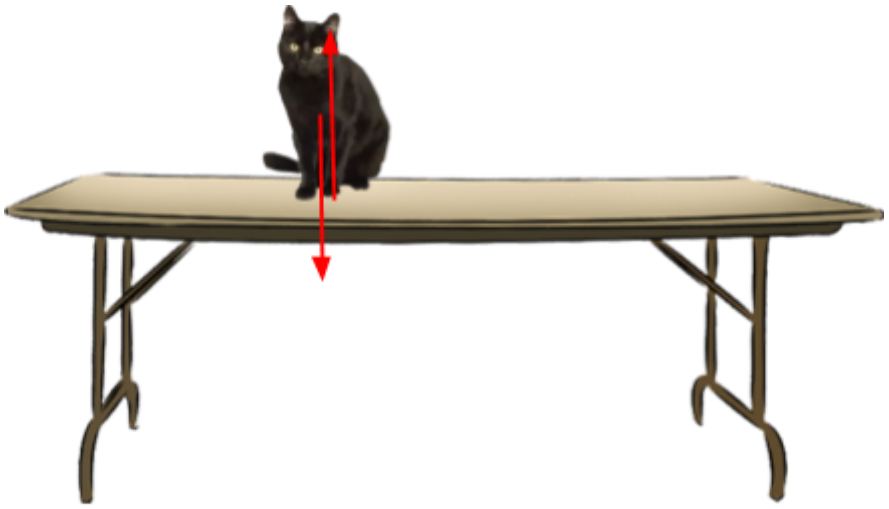
Gravity pulling the block down

The table pushing back up



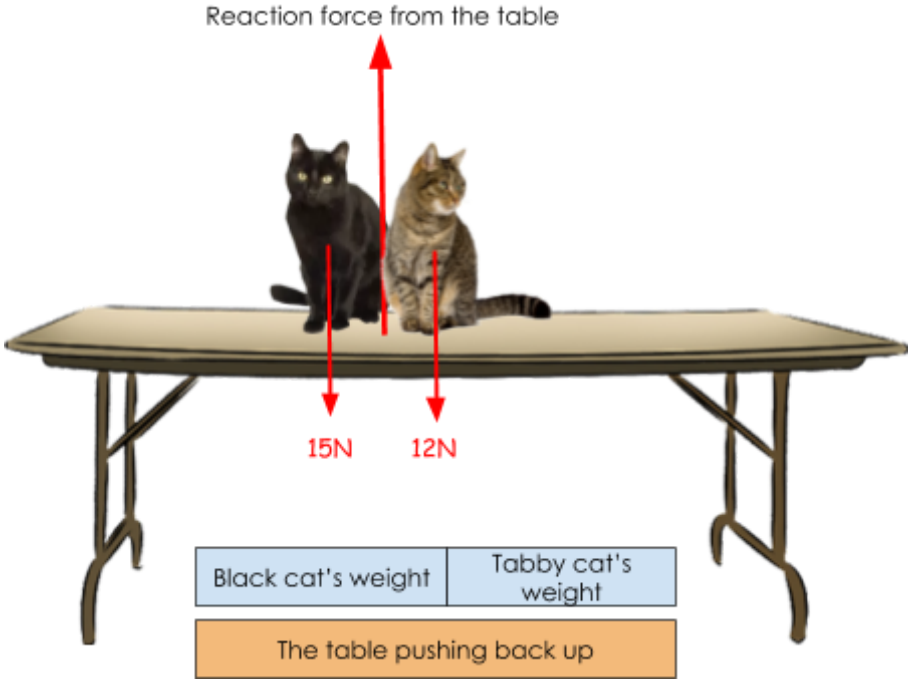
reaction

4.1N | 2.3N | 0.8N



The cat's weight

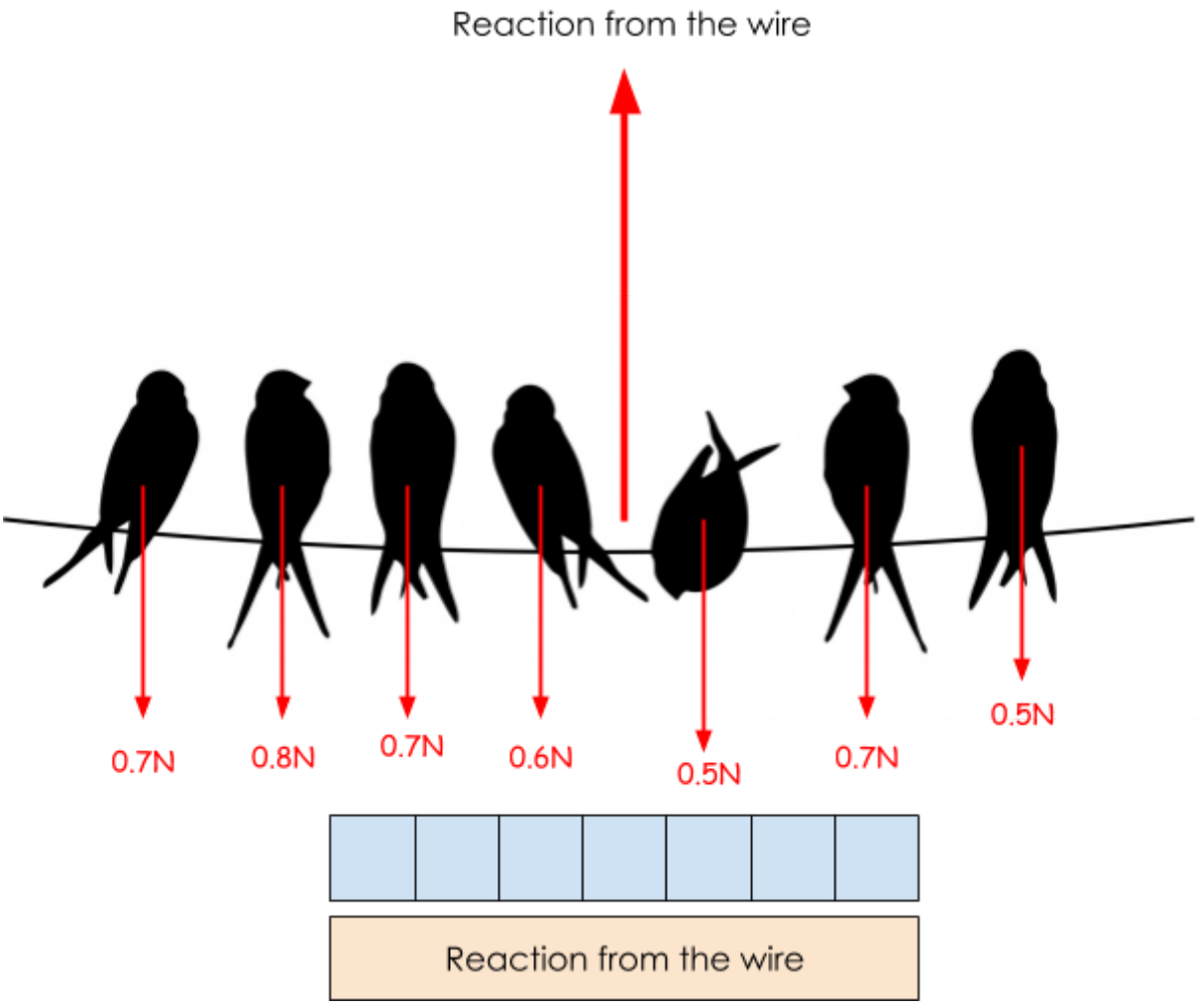
The table pushing back up



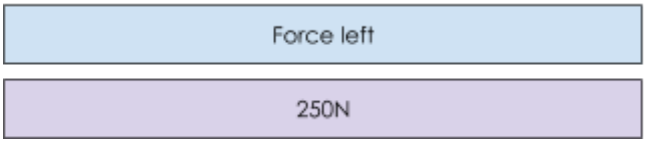
Black cat's weight | Tabby cat's weight

The table pushing back up

Birds on a Wire

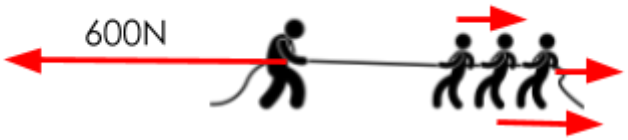


Tug of War (balanced forces)



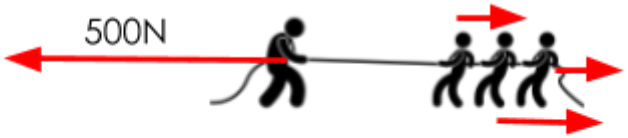
I do

3 friends play tug of war against a teacher. The forces are balanced. The teacher pulls with 600N. One friend pulls with 190N. Another pulls with 290N. How much force does the third friend pull with?



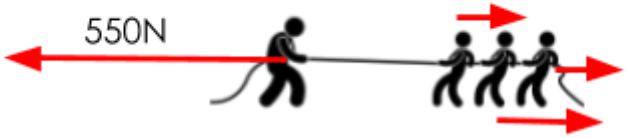
We do

3 friends play tug of war against a teacher. The forces are balanced. The teacher pulls with 500N. One friend pulls with 150N. Another pulls with 160N. How much force does the third friend pull with?

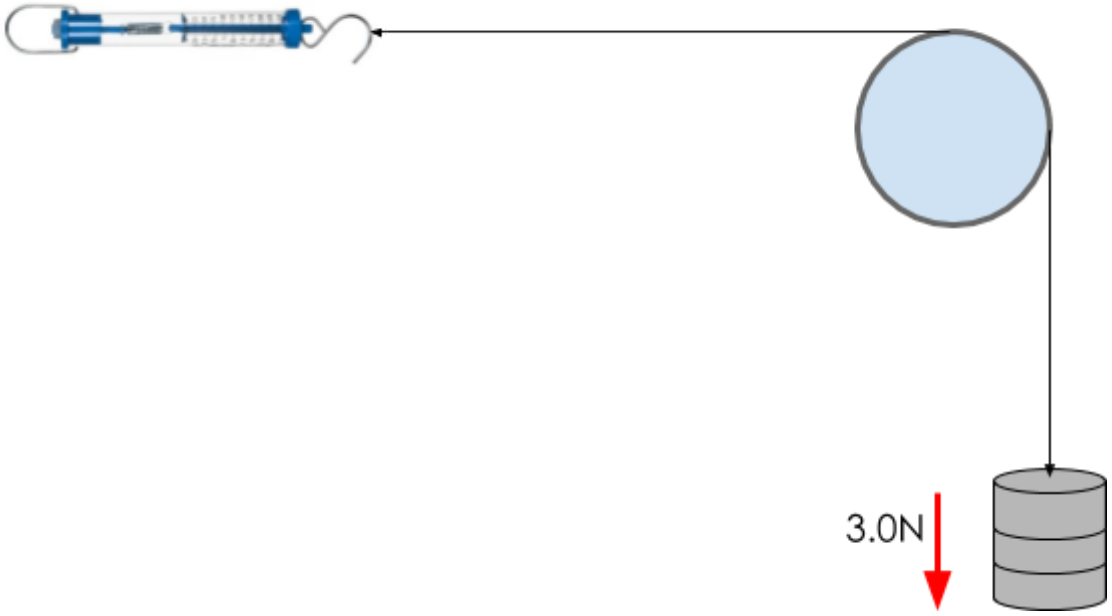


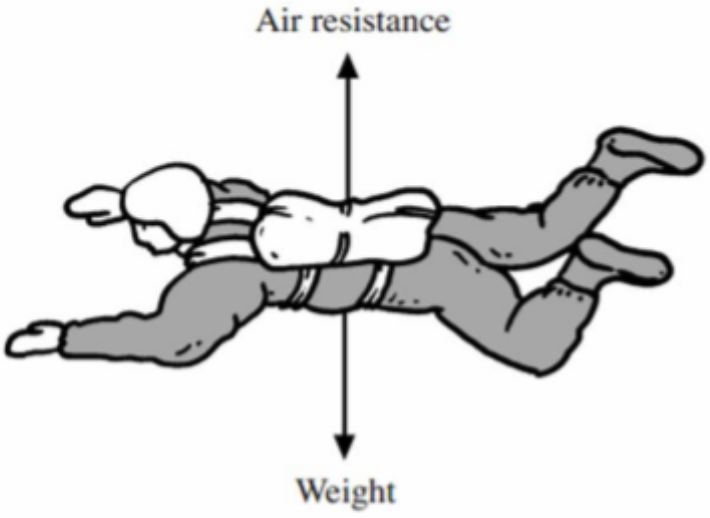
You do

3 friends play tug of war against a teacher. The forces are balanced. The teacher pulls with 550N. One friend pulls with 130N. Another pulls with 180N. How much force does the third friend pull with?



I do





If the forces are balanced, the skydiver will not speed up or slow down - she stays at the same speed!

Weight

Air Resistance

Rate Questions

Rate of growing

A bean plant grows 15cm every day. How many days will it take to reach the top of a 135cm fence?

Solution

Using a bar model: draw one bar representing 150cm and count the number of 15cm bars needed to make a bar the same length.

Speed Questions

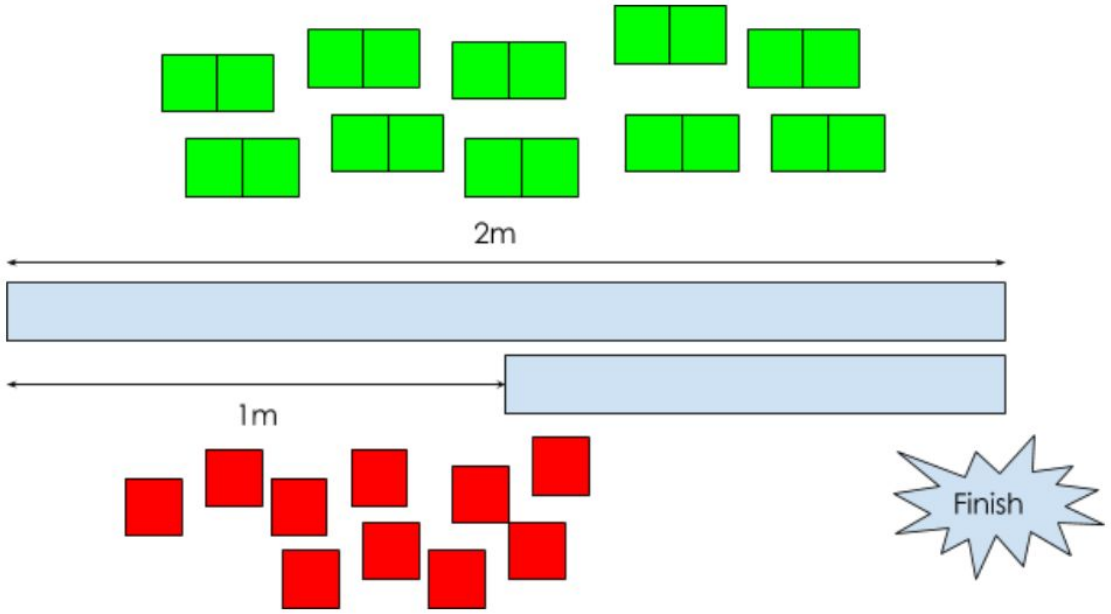
I do:

A snail and a slug are running a race. The slug is twice as fast as the snail, who has a heavy shell. The race is 2m long. The slug gives the snail a 1m head start. Who wins?

A: the slug
B; the snail
C: a draw

Solution (using bar model)

Each time the slug moves 2 places forwards, the snail moves one.
See how many goes it takes for the slug to finish the race.
See how many goes it takes for the snail to finish the race.



They both take 10 goes, so it is C: a draw.

We do:

An ant and a caterpillar run a race. The race is 1m long. The caterpillar is three times faster than the ant, so the caterpillar lets the ant have a 50cm head start. Who wins the race?

A: the caterpillar
B: the ant
C: it is a draw

You do

An sparrow and a blue-tit fly a race. The race is 100m long. The blue-tit is twice as fast as than the sparrow, so the blue-tit lets the sparrow have a 50m head start. Who wins the race?

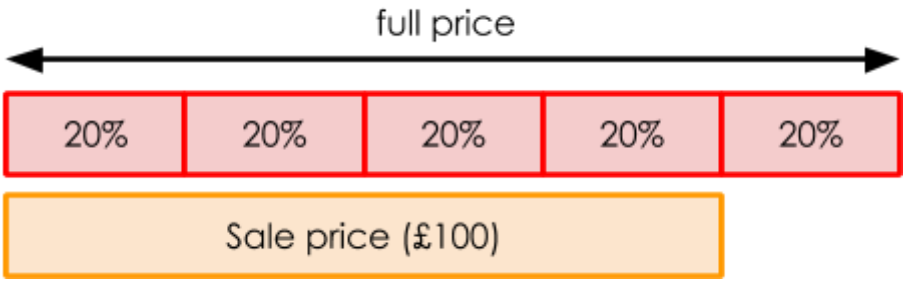
A: the sparrow
B: the blue-tit
C: it is a draw

Using Percentages (e.g. efficiency)

An example maths question with bar-model visual representation:

> *A refrigerator is in the sales. It is 20% off and now costs £100. How much was the original price?*
>
> *A: £75*
>
> *B: £80*
>
> *C: £120*
>
> *D: £125*

Model answer using the bar-model:



20% is $\frac{1}{4}$ of £100 = £25

So 100% is 5 x £25 = £125

A Physics Example

An LED is 80% efficient. If it produces 100J of light, how much electrical energy did it use?

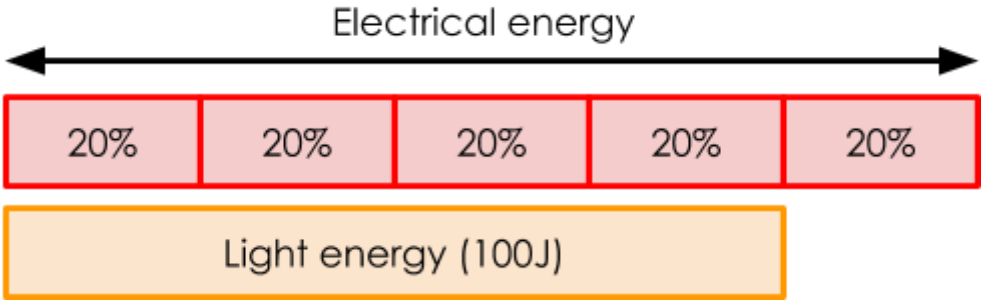
A: 75J

B: 80J

C: 120J

D: 125J

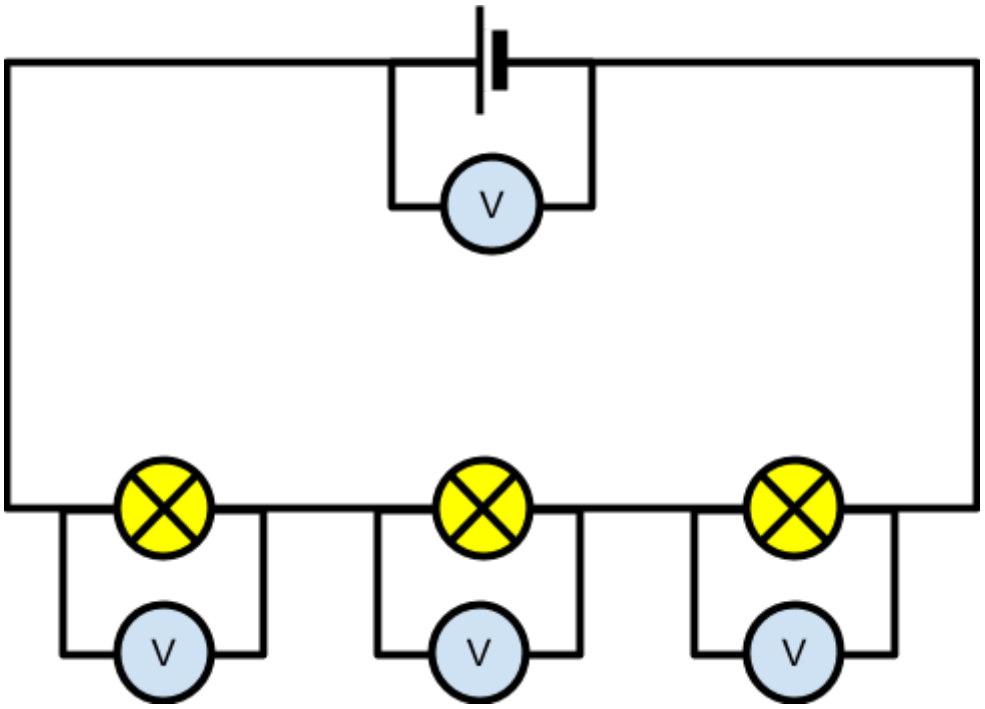
Model answer using bar-model:



20% is $\frac{1}{4}$ of 100J = 25J

∴100% is 5 x 25 = 125J

Electricity Questions: Voltage in Series Circuits

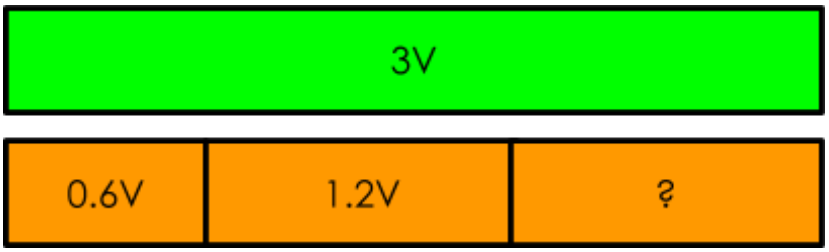


I do: voltage across bulbs in series

If the voltage drops an equal amount across each bulb, what will the readings on the three voltmeters be?

We do: voltage across bulbs in series

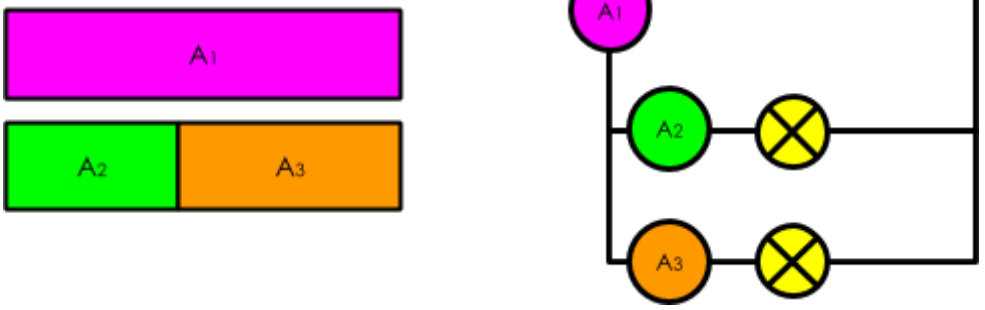
If the voltage drops 0.6V across the left-hand bulb and 1.2V across the middle bulb, what will the reading be on the third voltmeter?



You do: voltage across bulbs in series

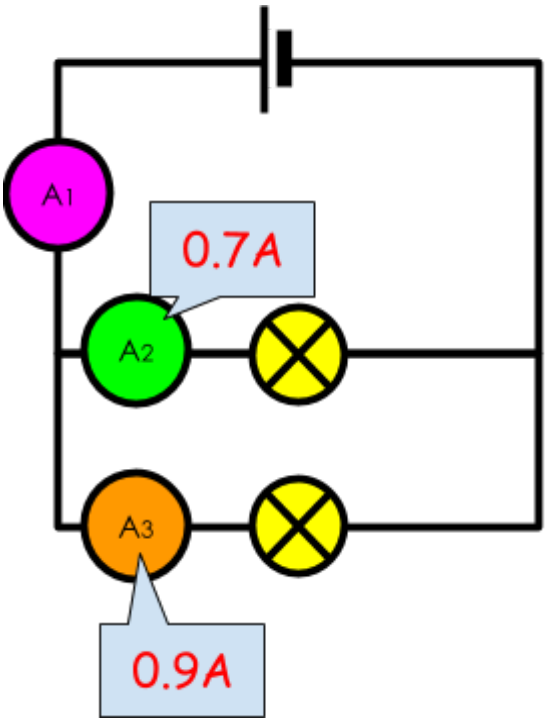
If the voltage drops 0.5V across the left-hand bulb and 0.5V across the right-hand bulb, what will the reading be on the middle voltmeter?

Electricity Questions: Current in Parallel Circuits



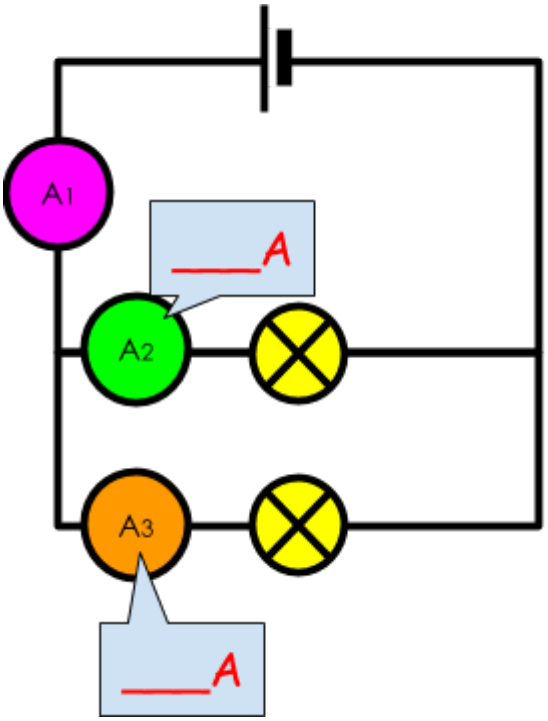
I do:

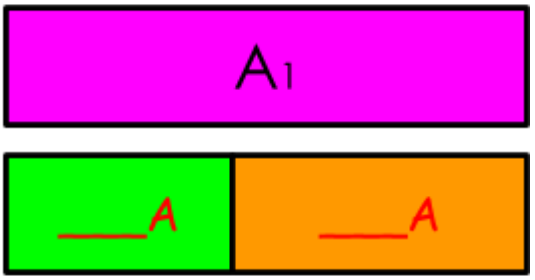
If the current through A_2 is 0.7A and the current through A_3 is 0.9A, what is the current through A_1?



We do:

If the current through A_2 is 0.5A and the current through A_3 is 0.6A, what is the current through A_1?



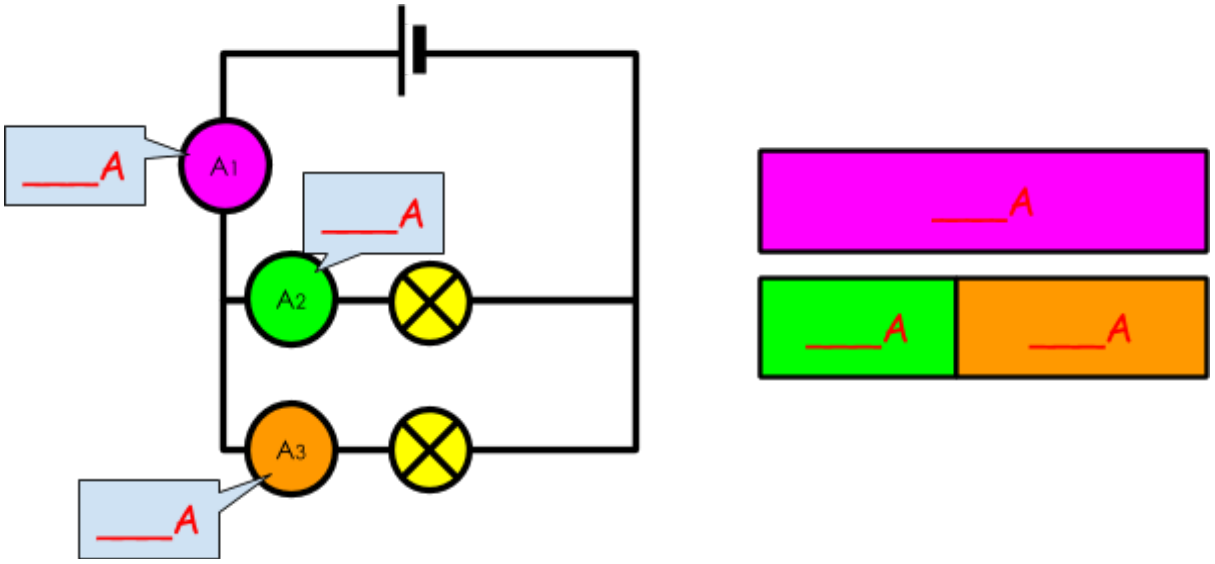


You do:

If the current through A_2 is 1.2A and the current through A_3 is 0.9A, what is the current through A_1?

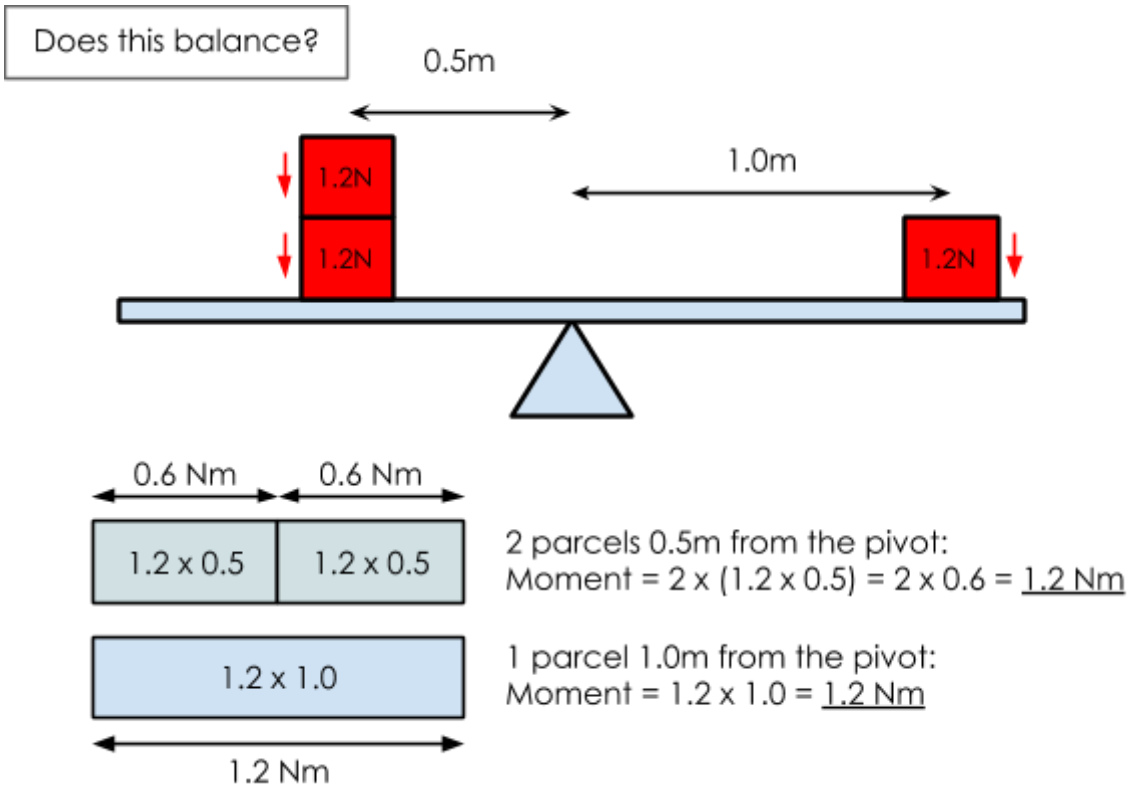
Extension:

If the current through A_1 is 1.2A and the current through A_2 is 0.9A, what is the current through A_3?

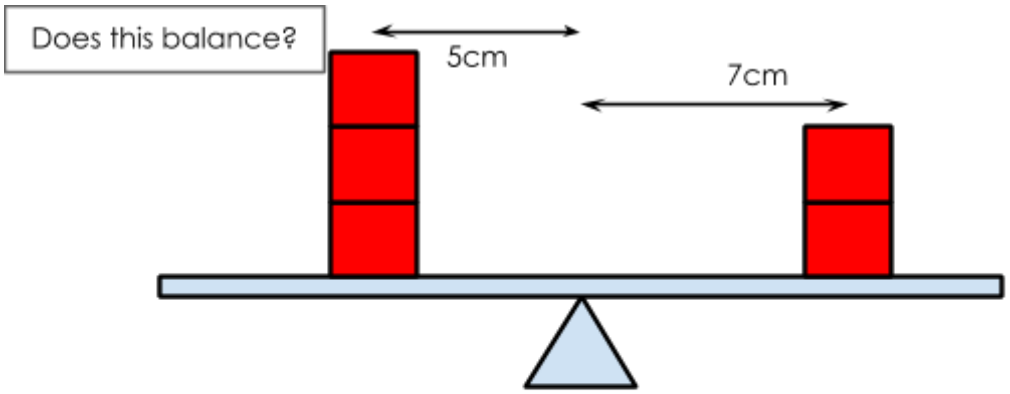


Moments Questions

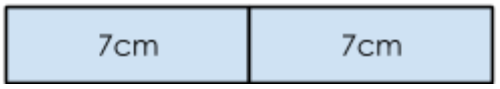
I do



We do

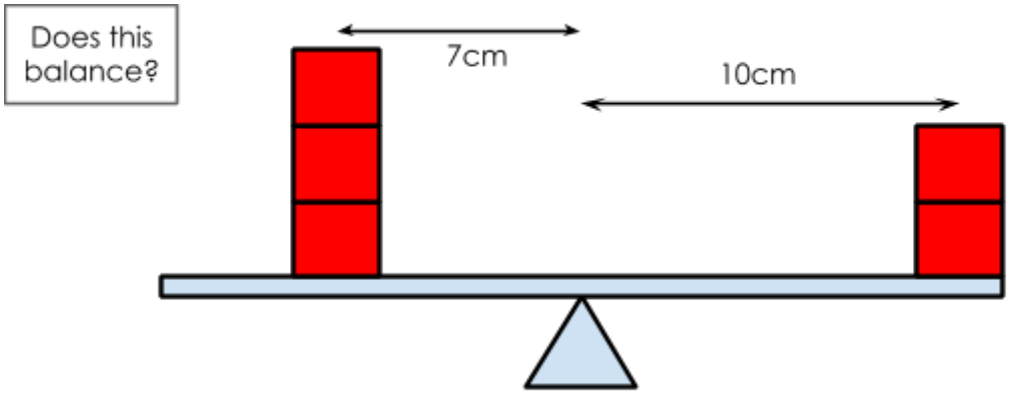


3 parcels each 5cm from the pivot.



2 parcels each 7cm from the pivot.

You do



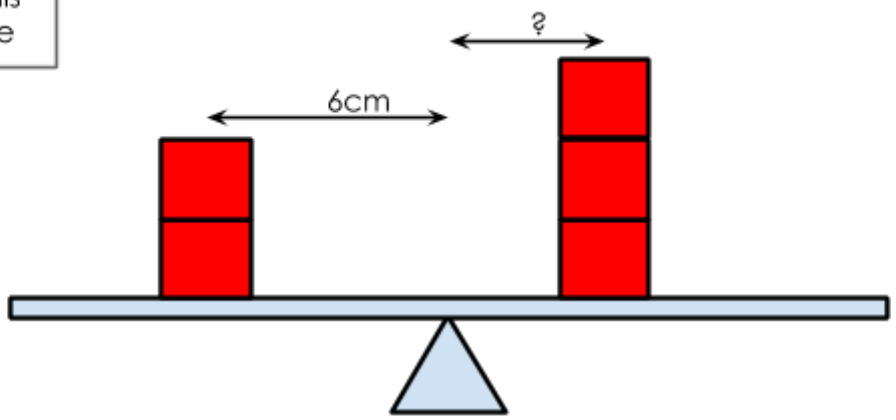
3 parcels each 7cm from the pivot.

2 parcels each 10cm from the pivot.

Moments - Missing Distance

I do

Make this balance

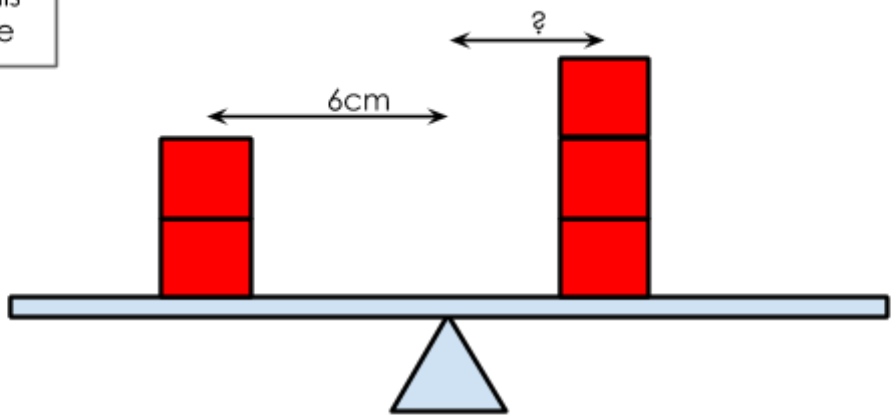


6cm	6cm	3 parcels each 6cm from the pivot.
?	? ?	3 parcels each _____ from the pivot.

Moments - Missing Distance

I do

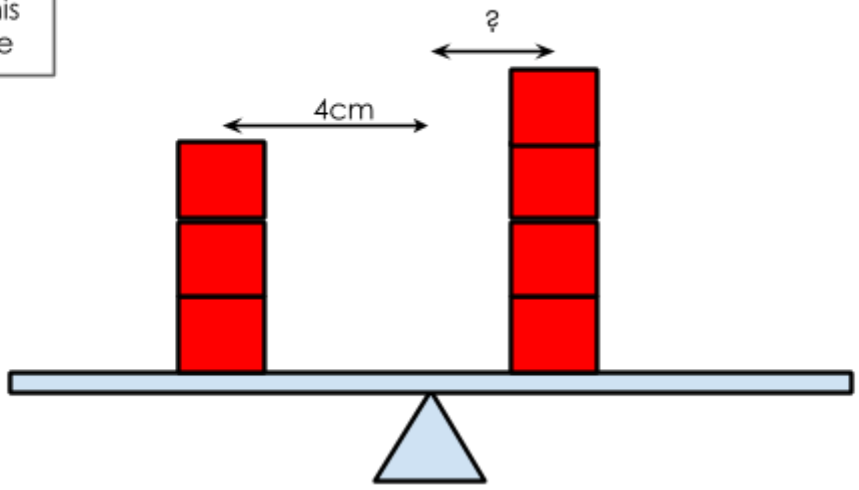
Make this balance



6cm	6cm		2 parcels each 6cm from the pivot.
?	?	?	3 parcels each 4cm from the pivot.

We do

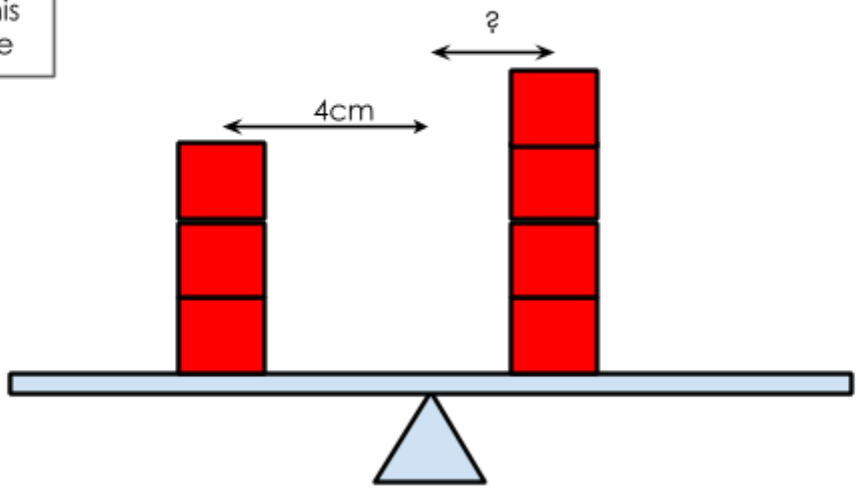
Make this balance



4cm	4cm	4cm	3 parcels each 4cm from the pivot.
?	?	?	?	4 parcels each _____ from the pivot.

You do

Make this balance

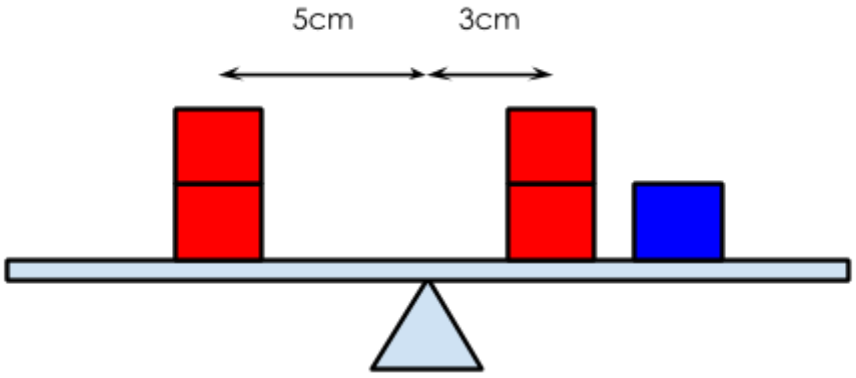


4cm	4cm	4cm	3 parcels each 4cm from the pivot.
?	?	?	?	4 parcels each _____ from the pivot.

Moments - Multiple Distances

We do

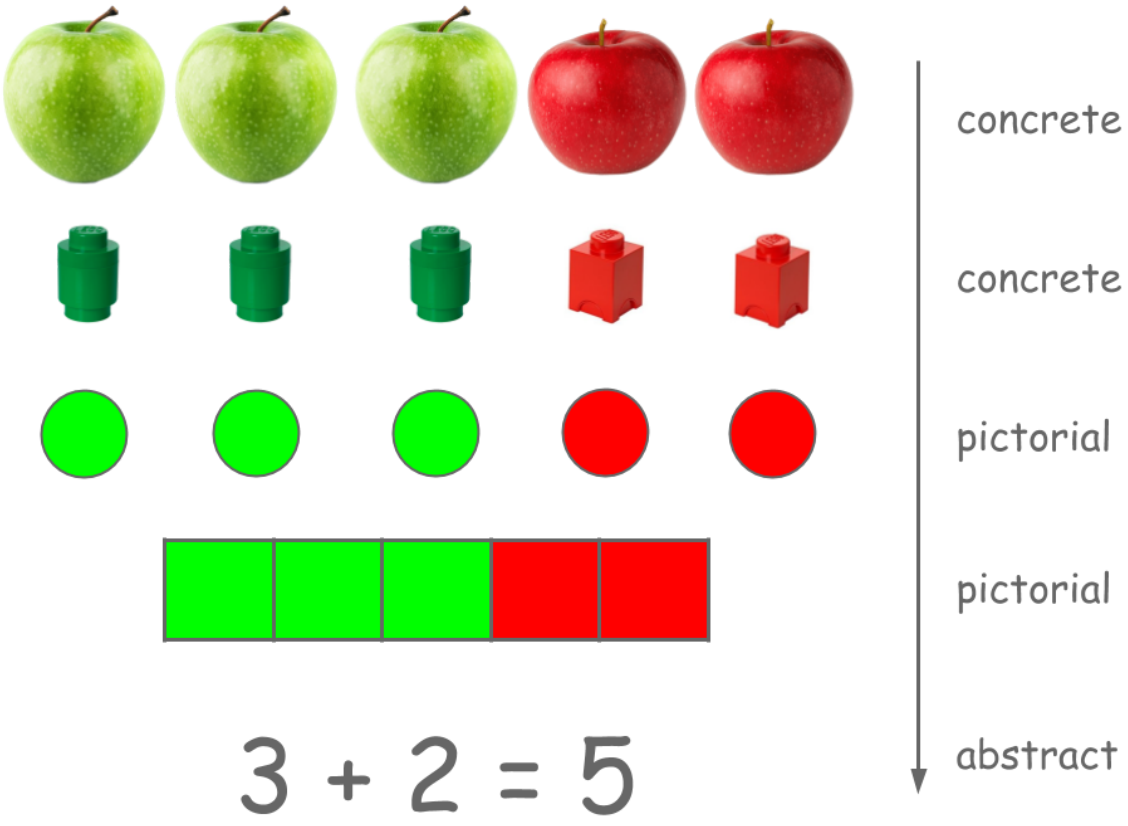
Make this balance



2 parcels each 5cm from the pivot.

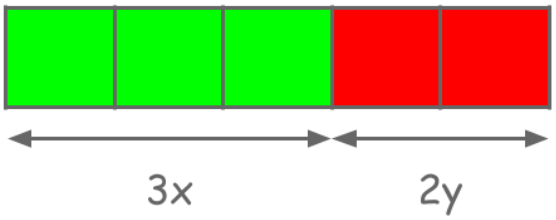
2 parcels each 3cm from the pivot plus 1 parcel _____ from the pivot.

CPA - Concrete, pictorial, abstract.



CPA also works for algebra

pictorial



pictorial

$$3x + 2y$$

abstract