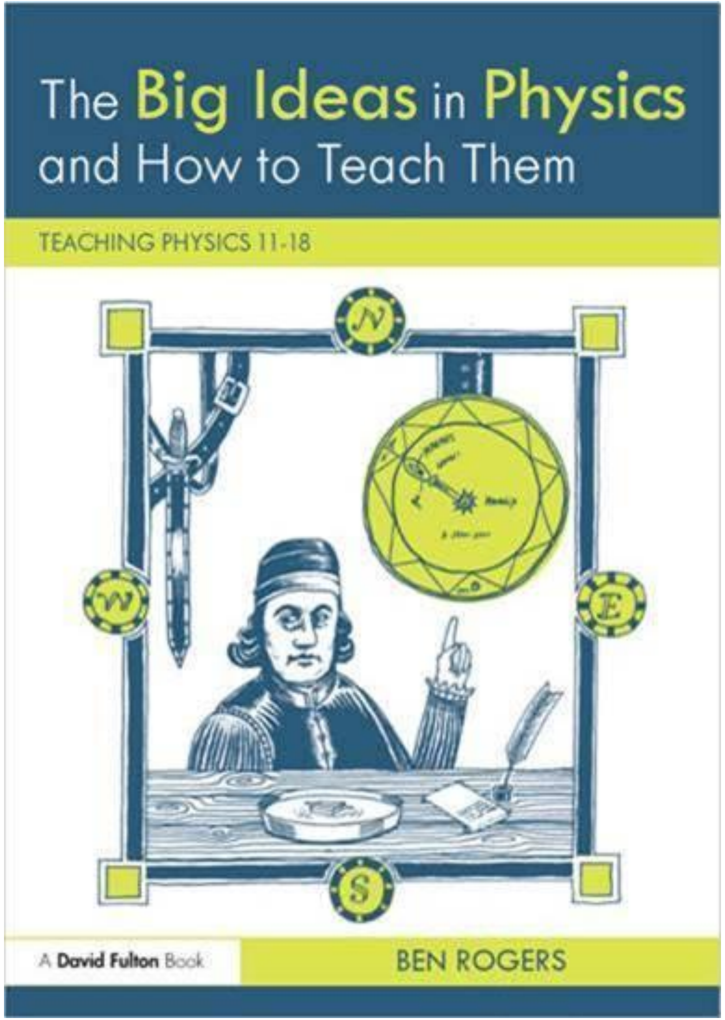
A physicist is the sum of the problems she can solve.

Ben Rogers



Part #1 Problem solving is knowledge

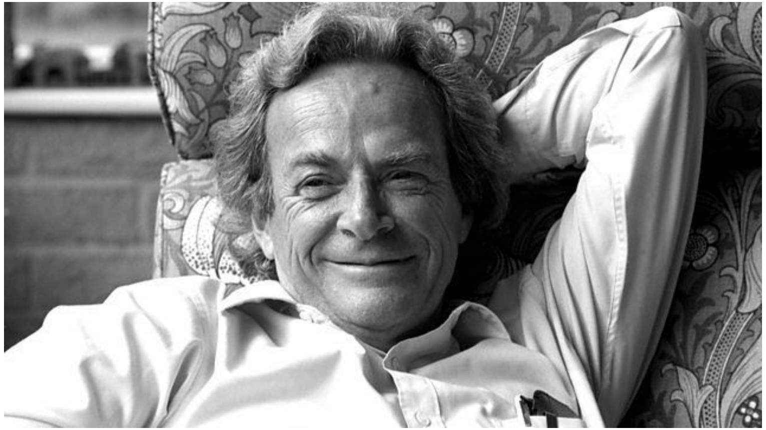
Great physicists are not born, they are made, problem by problem.

..the science student, confronted with a problem, seeks to see it as like one or more of the exemplary problems he has encountered before.

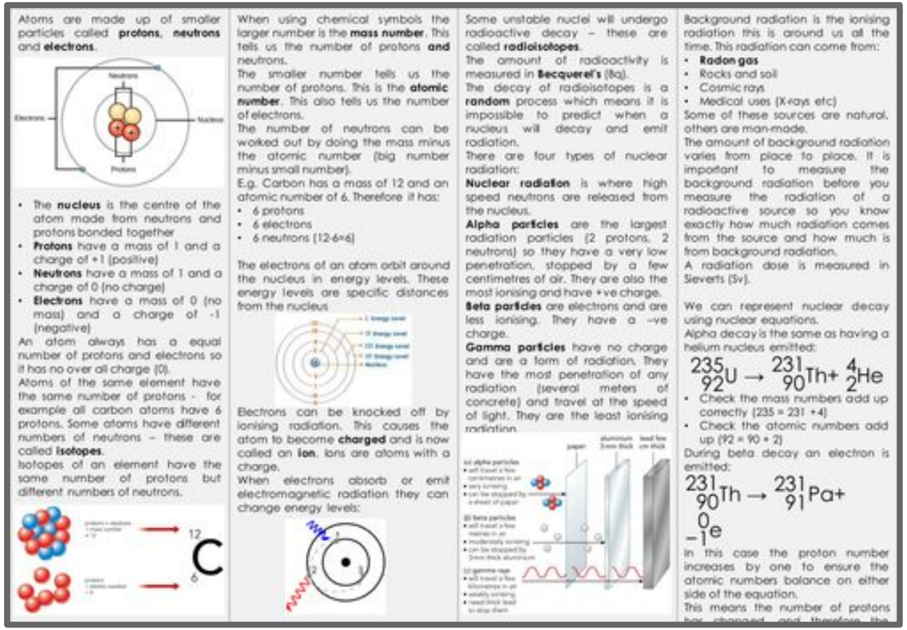
Thomas Kuhn 1977: 297

Know how to solve every problem that has been solved.

Richard Feynman



From Knowledge Organisers to Problem Solving



Atoms are made up of smaller particles called **protons**, **neutrons** and **electrons**.

- The **nucleus** is the centre of the atom made from neutrons and protons bonded together
- **Protons** have a mass of 1 and a charge of +1 (positive)
- **Neutrons** have a mass of 1 and a charge of 0 (no charge)
- **Electrons** have a mass of 0 (no mass) and a charge of -1 (negative)

An atom always has a equal number of protons and electrons so it has no over all charge (0).
Atoms of the same element have the same number of protons - for example all carbon atoms have 6 protons. Some atoms have different numbers of neutrons – these are called **isotopes**.
Isotopes of an element have the same number of protons but different numbers of neutrons.

When using chemical symbols the larger number is the **mass number**. This tells us the number of protons **and** neutrons.
The smaller number tells us the number of protons. This is the **atomic number**. This also tells us the number of electrons.
The number of neutrons can be worked out by doing the mass minus the atomic number (big number minus small number).
E.g. Carbon has a mass of 12 and an atomic number of 6. Therefore it has:

- 6 protons
- 6 electrons
- 6 neutrons (12-6=6)

The electrons of an atom orbit around the nucleus in energy levels. These energy levels are specific distances from the nucleus

Electrons can be knocked off by ionising radiation. This causes the atom to become **charged** and is now called an **ion**. Ions are atoms with a charge.
When electrons absorb or emit electromagnetic radiation they can change energy levels:

Some unstable nuclei will undergo radioactive decay – these are called **radioisotopes**.
The amount of radioactivity is measured in **Becquerel's** (Bq).
The decay of radioisotopes is a **random** process which means it is impossible to predict when a nucleus will decay and emit radiation.
There are four types of nuclear radiation:
Nuclear radiation is where high speed neutrons are released from the nucleus.
Alpha particles are the largest radiation particles (2 protons, 2 neutrons) so they have a very low penetration, stopped by a few centimetres of air. They are also the most ionising and have +ve charge.
Beta particles are electrons and are less ionising. They have a -ve charge.
Gamma particles have no charge and are a form of radiation. They have the most penetration of any radiation (several meters of concrete) and travel at the speed of light. They are the least ionising radiation.

Background radiation is the ionising radiation this is around us all the time. This radiation can come from:

- **Radon gas**
- Rocks and soil
- Cosmic rays
- Medical uses (X-rays etc)

Some of these sources are natural, others are man-made.
The amount of background radiation varies from place to place. It is important to measure the background radiation before you measure the radiation of a radioactive source so you know exactly how much radiation comes from the source and how much is from background radiation.
A radiation dose is measured in Sieverts (Sv).

We can represent nuclear decay using nuclear equations.
Alpha decay is the same as having a helium nucleus emitted:

$$^{235}_{92}U \rightarrow ^{231}_{90}Th + ^{4}_{2}He$$

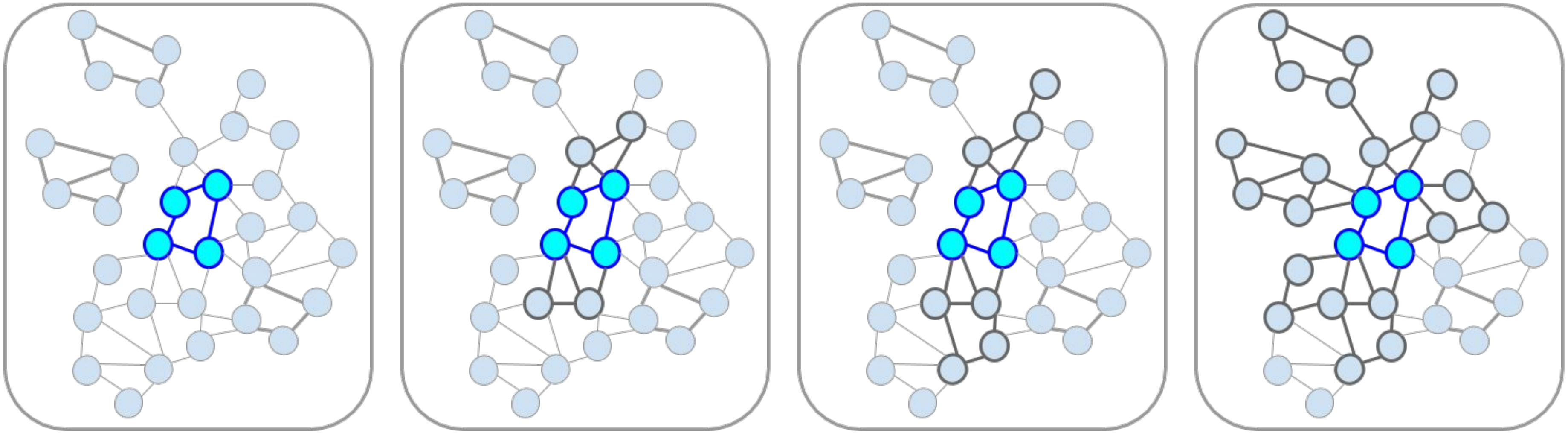
- Check the mass numbers add up correctly (235 = 231 +4)
- Check the atomic numbers add up (92 = 90 + 2)

During beta decay an electron is emitted:

$$^{231}_{90}Th \rightarrow ^{231}_{91}Pa + ^{0}_{-1}e$$

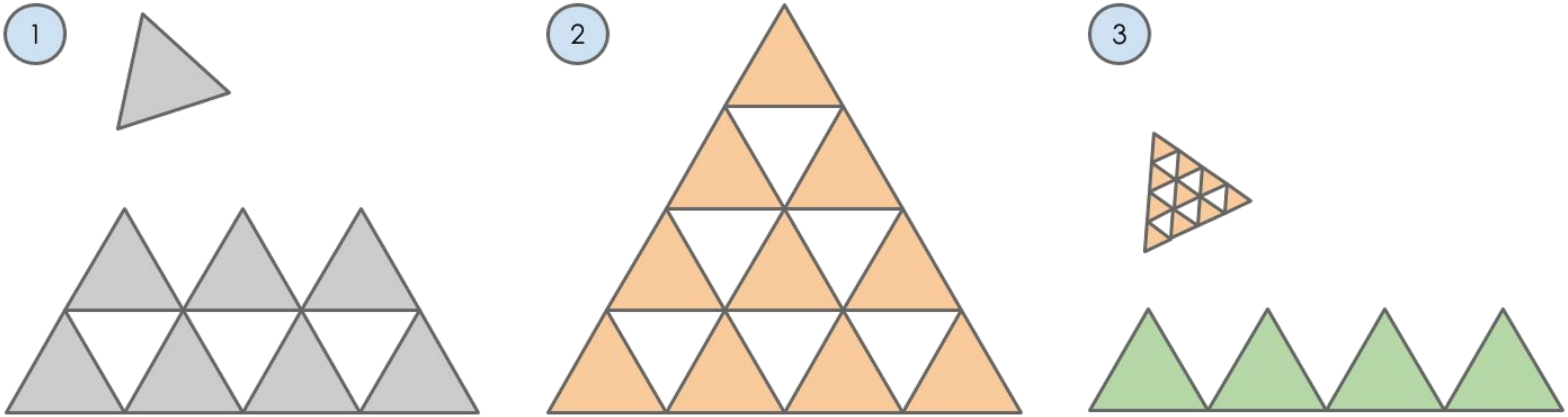
In this case the proton number increases by one to ensure the atomic numbers balance on either side of the equation.
This means the number of protons

AQA Physics 9-1 Knowledge Organiser - Atomic Structure (4.4) - Revision by jkrtaylor - Teaching Resources - Tes

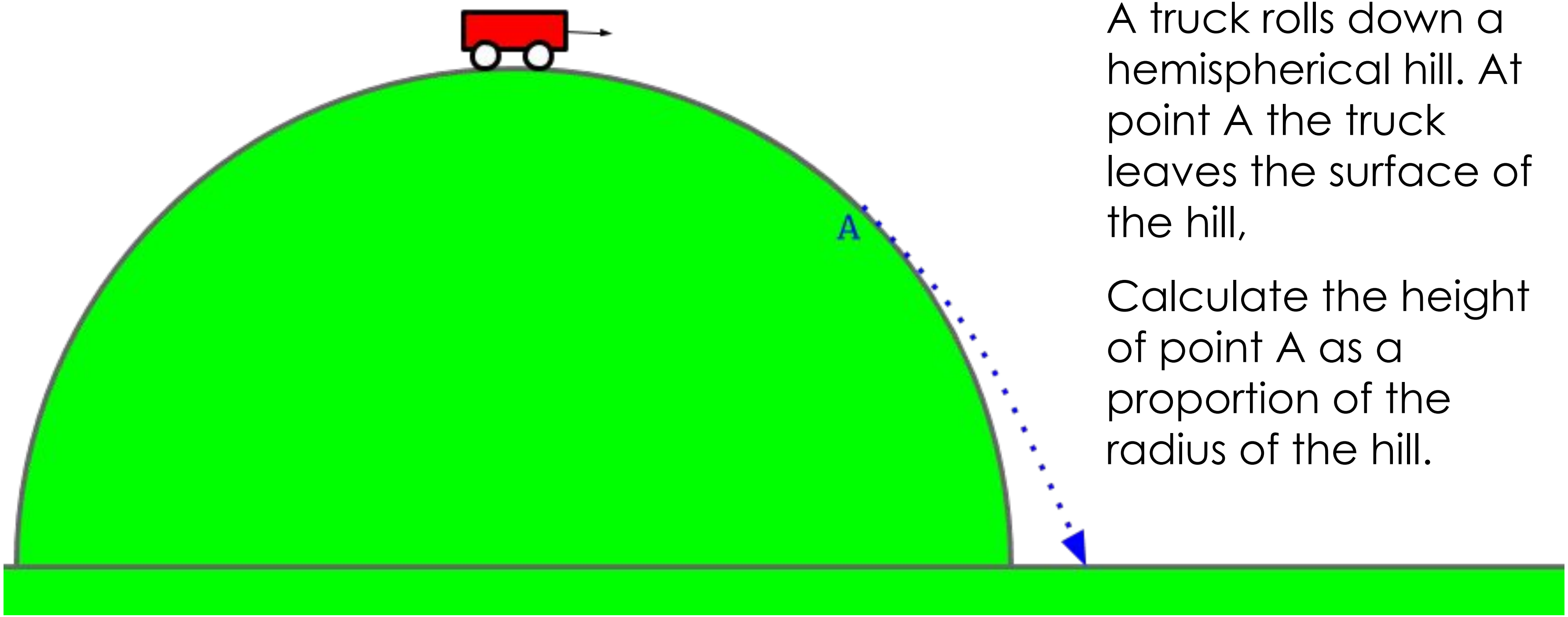


know understand use master

Efrat Furst

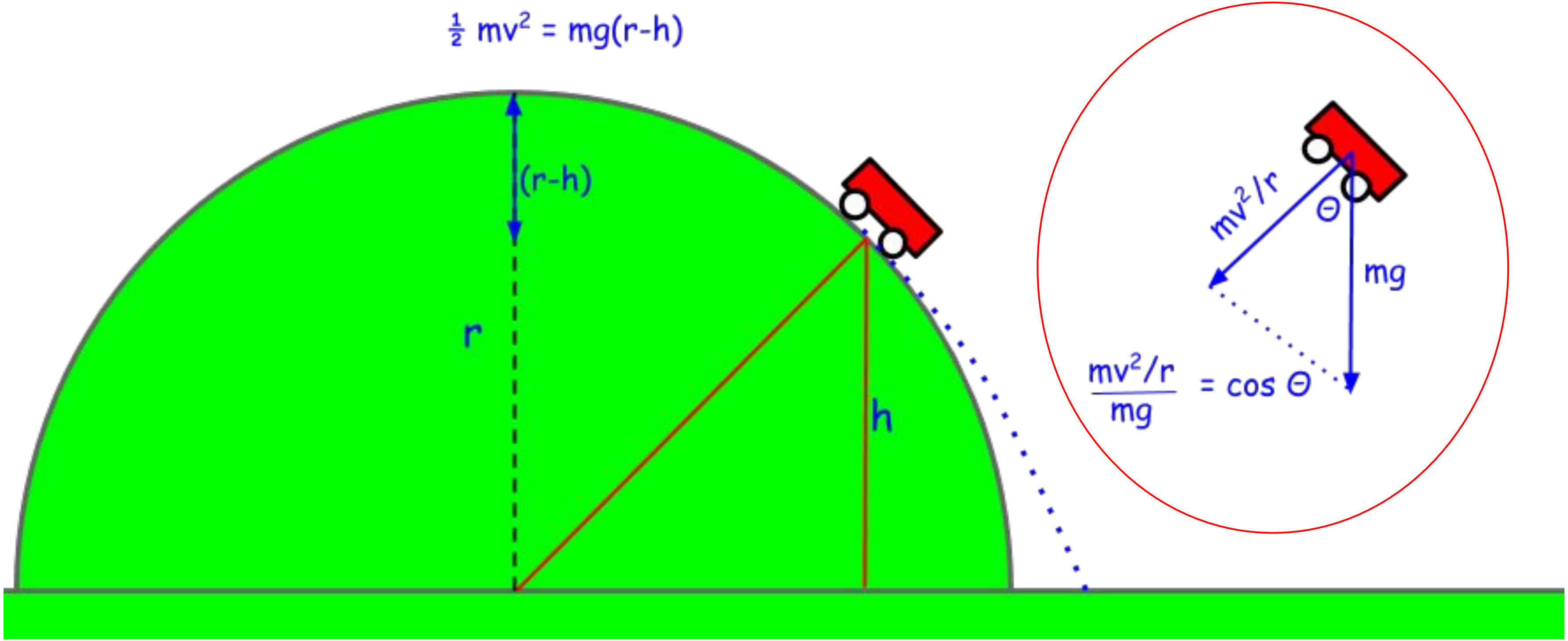


Efrat Furst



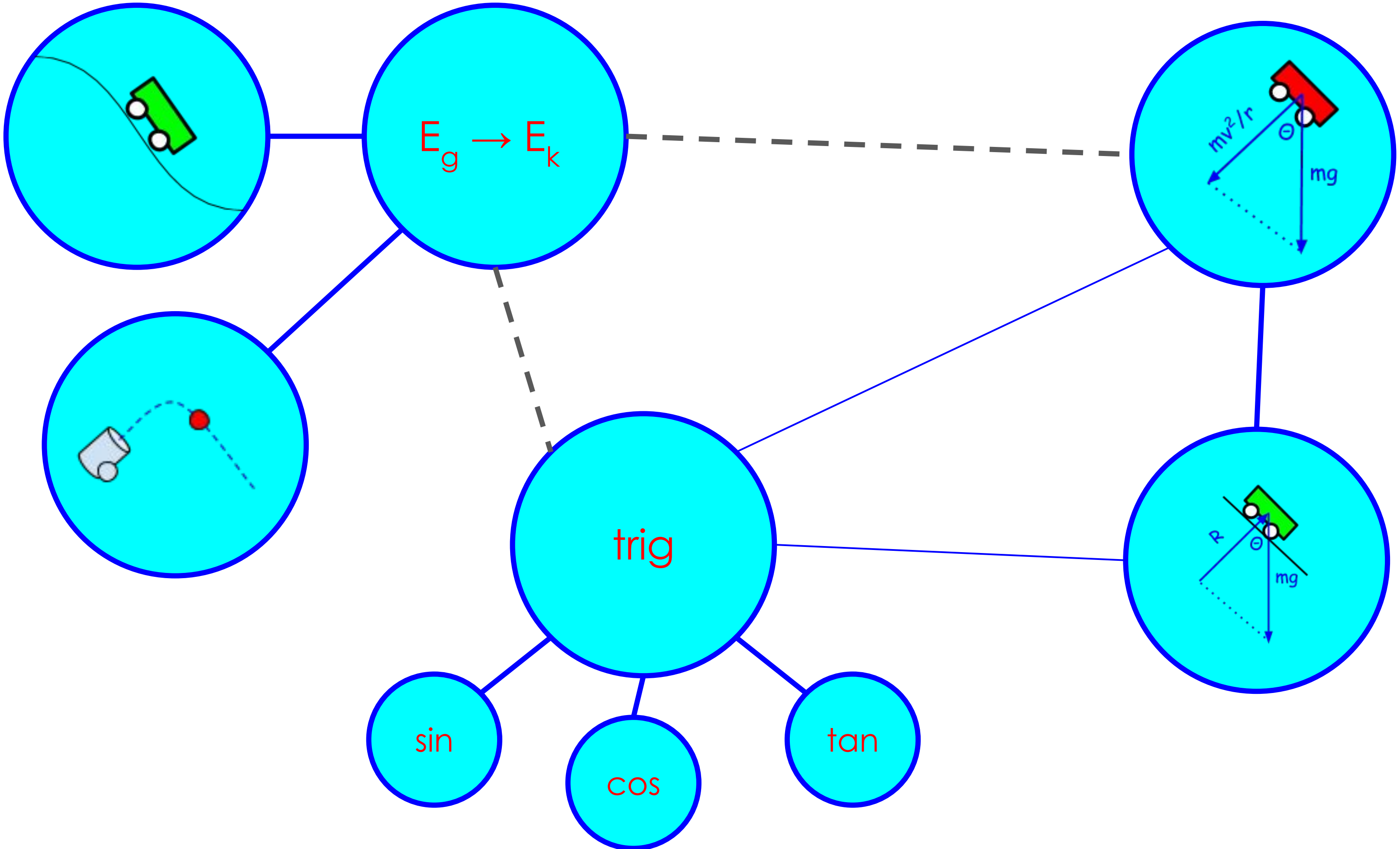
A truck rolls down a hemispherical hill. At point A the truck leaves the surface of the hill,

Calculate the height of point A as a proportion of the radius of the hill.

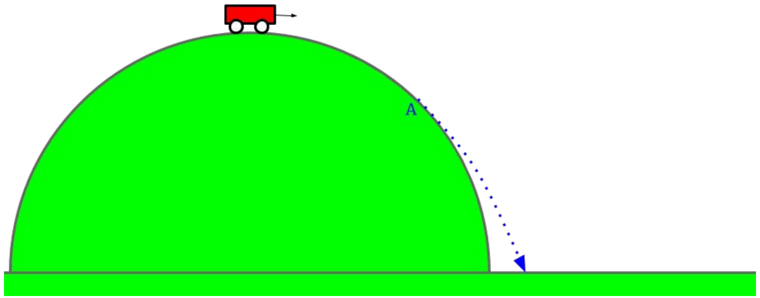


Motion in a circle ($F=mv^2/r$)
$E_g \rightarrow E_k$
Trigonometry

Ignore friction
Ignore the energy stored in KE of the wheels.
~~Suvat~~



$E_g \rightarrow E_k$
mv^2/r
Θ
mg
R
Θ
mg
trig
sin
cos
tan



..the science student, confronted with a problem, seeks to see it as like one or more of the exemplary problems he has encountered before.

Always ask extension questions:

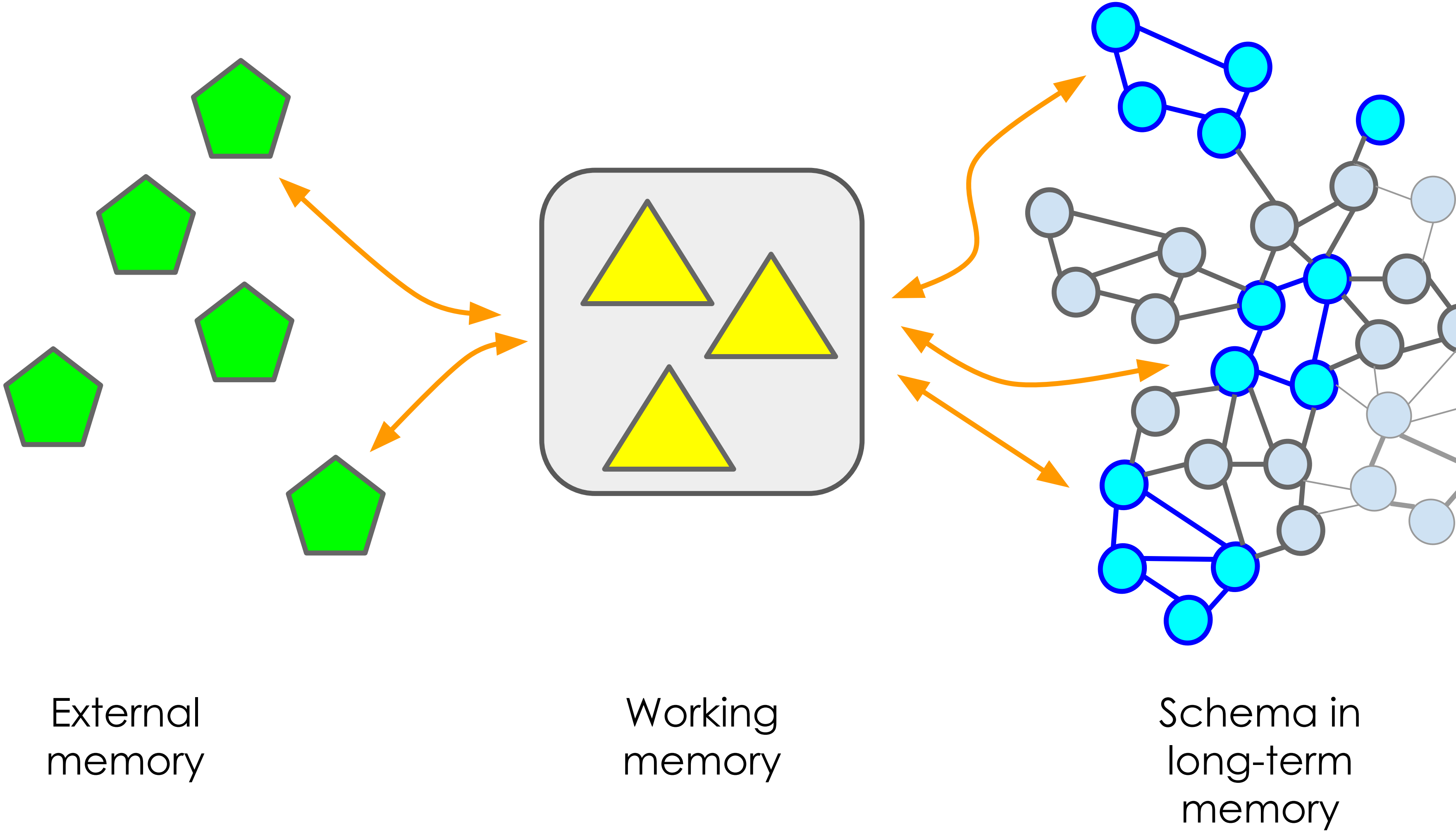
- What would happen if the hill was on the Moon?
- What would happen if the hill was straight/parabolic?
- What would happen if you considered friction?
- What would happen if you considered the angular momentum of the wheels?
- What would happen if you used a ball?

Part #2 Why knowledge is important for problem solving: Cognitive Load Theory

Cognitive Load Theory

1. We solve problems using working memory.
2. Working memory can hold very little new knowledge.
3. Working memory can draw on long-term memory with very little effort.
4. When working memory is ‘full’, we cannot make changes to working memory.

John Sweller


External memory
Working memory
Schema in long-term memory

Takeaway: reducing Cognitive Load allows more efficient transfer of knowledge to long-term memory.

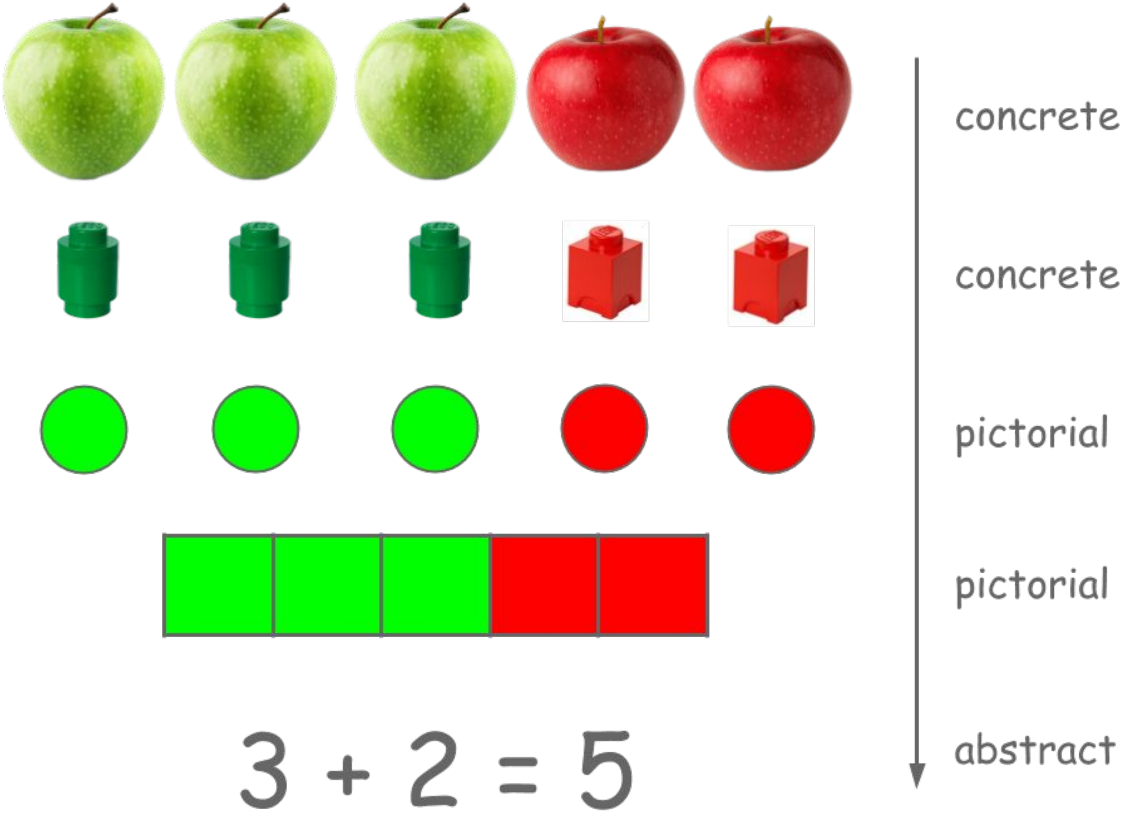
Part #3 Reducing the Cognitive Load of a problem using bar-model

... the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it.

Eugene Wigner

Mathematics is the language in which God has written the universe

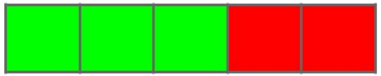
Galileo Galilei


concrete
concrete
pictorial
pictorial
abstract
3 + 2 = 5

concrete

concrete

pictorial

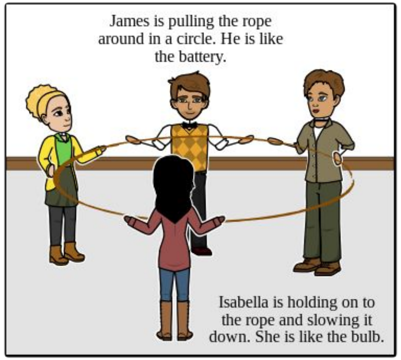


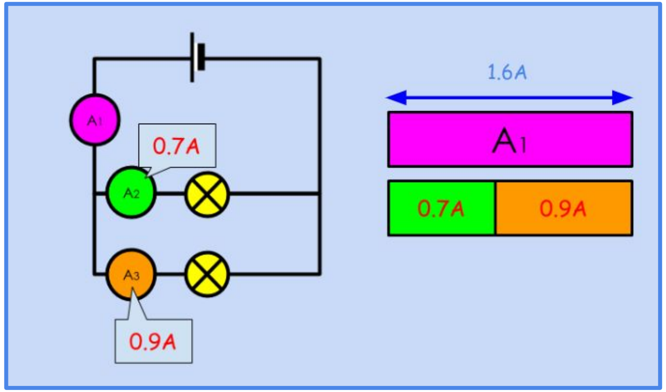
pictorial

$$3 + 2 = 5$$

abstract

THE ROPE MODEL





$$A_1 = A_2 + A_3$$

TTYP

What is the most common **incorrect** answer?

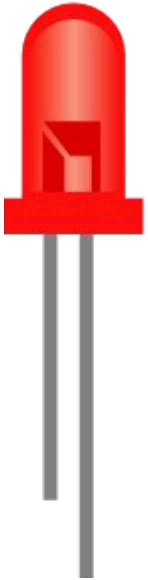
An LED is 80% efficient. If it produces 100J of light, how much electrical energy did it use?

A: 75J

B: 80J

C: 120J

D: 125J



TTYP

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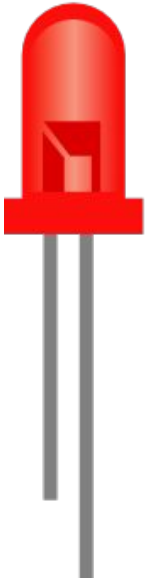
An LED is 80% efficient. If it produces 100J of light, how much electrical energy did it use?

A: *75J*

B: *80J*

C: *120J* ⭐

D: *125J*



TTYP

How does this bar-model help your learners?

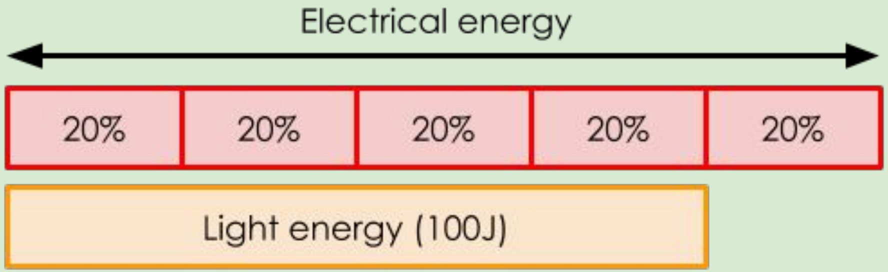
An LED is 80% efficient. If it produces 100J of light, how much electrical energy did it use?

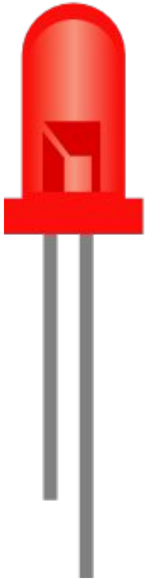
A: 75J

B: 80J

C: 120J

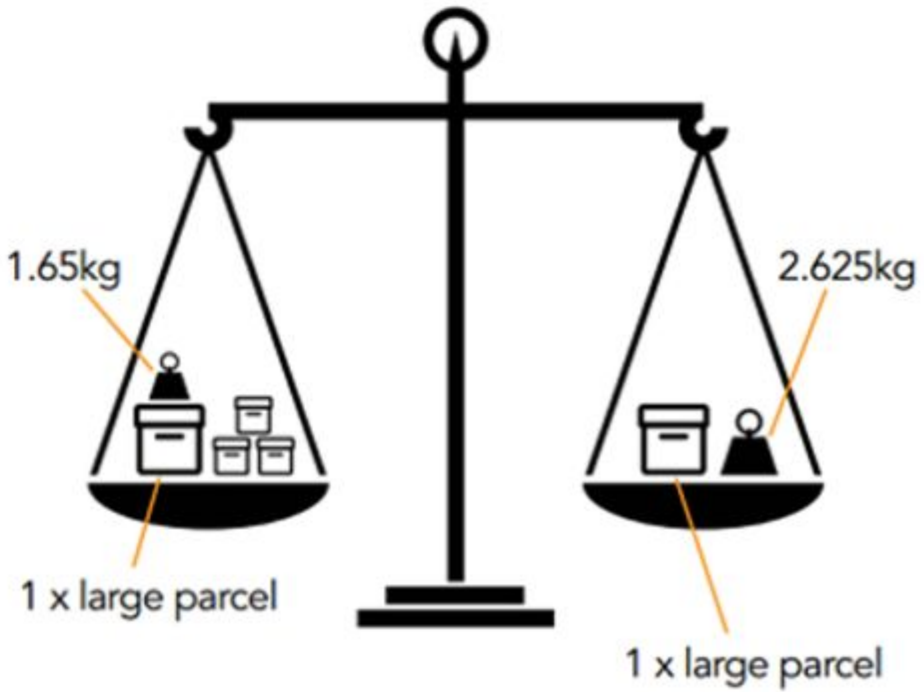
D: 125J





This diagram shows some parcels on a balance scale. Each small parcel is identical.

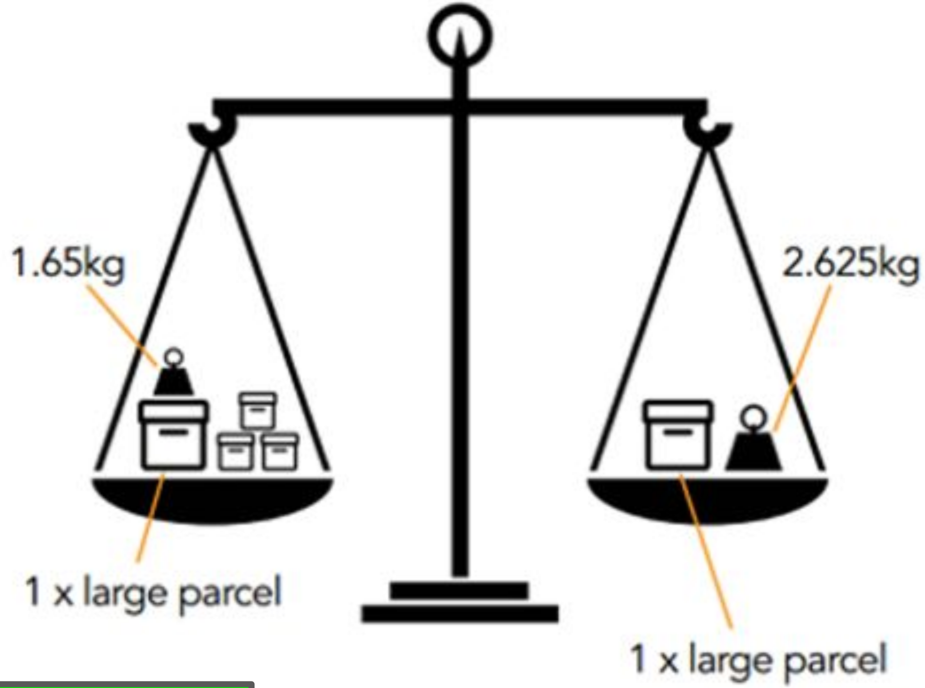
Calculate the mass of **one** small parcel, in grammes.



KS2 SATs question

This diagram shows some parcels on a balance scale. Each small parcel is identical.

Calculate the mass of **one** small parcel, in grammes.



left side

right side

KS2 SATs question

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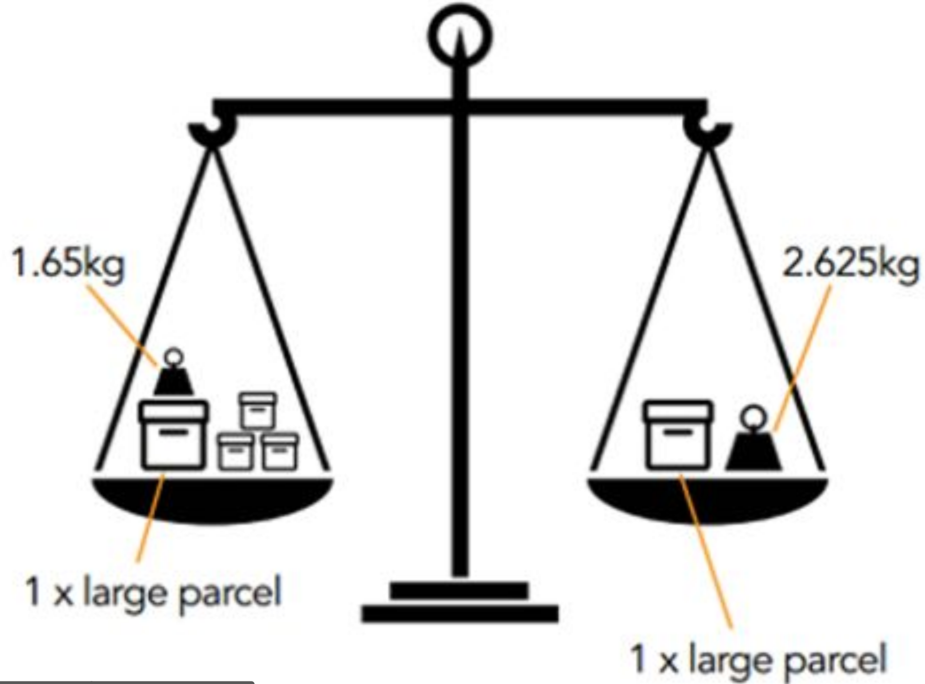

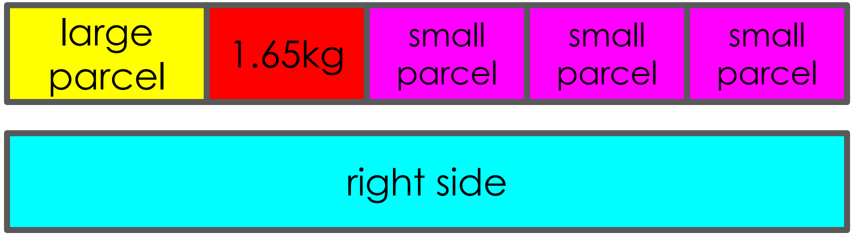

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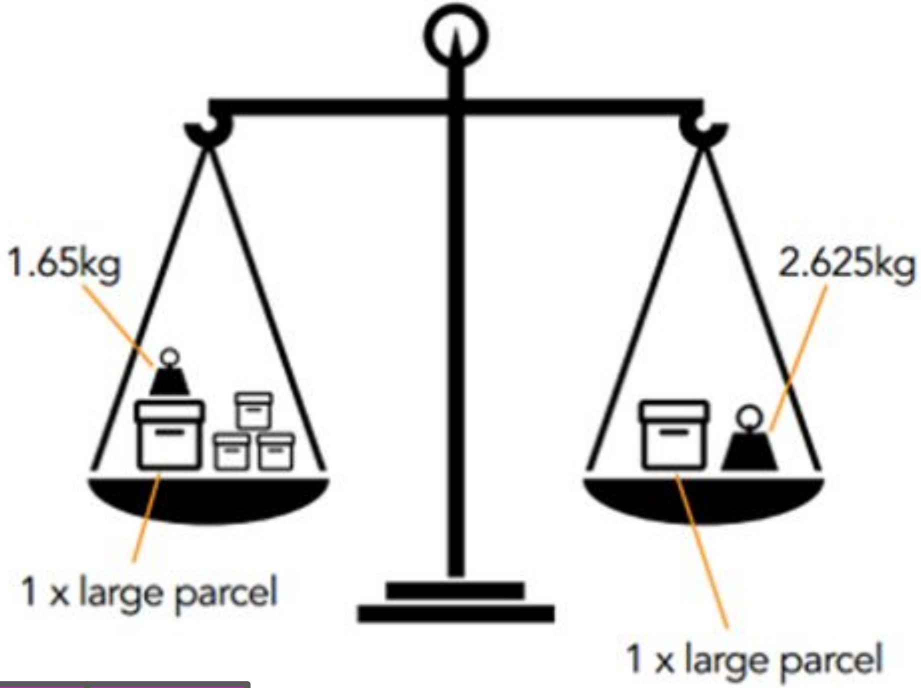

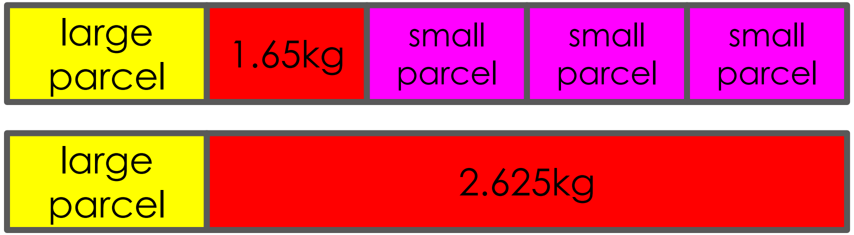

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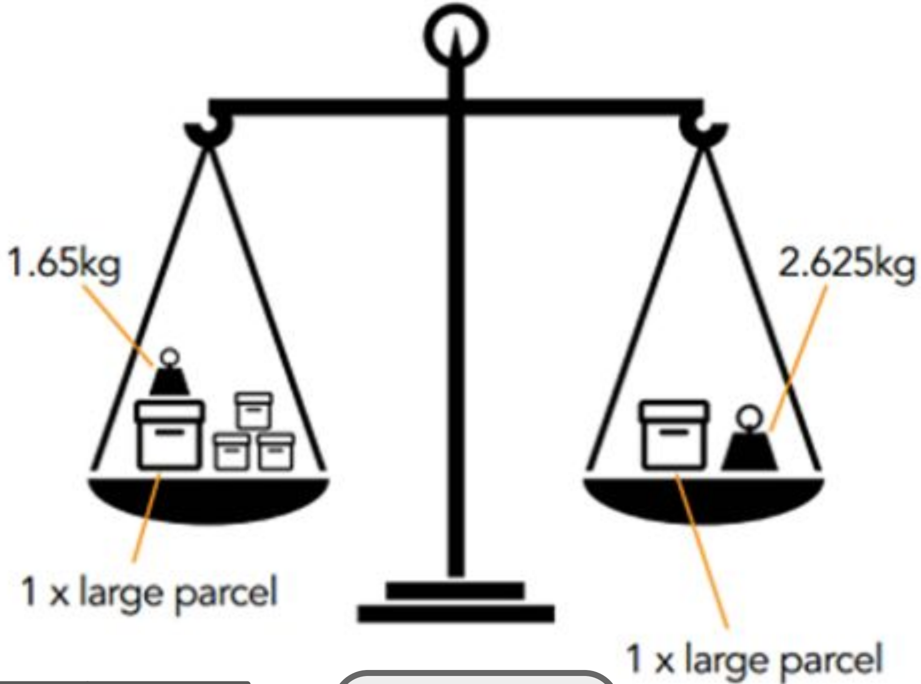
Calculate the mass of **one** small parcel, in grammes.



large parcel	1.65kg
large parcel	1.65kg

small parcel	small parcel	small parcel

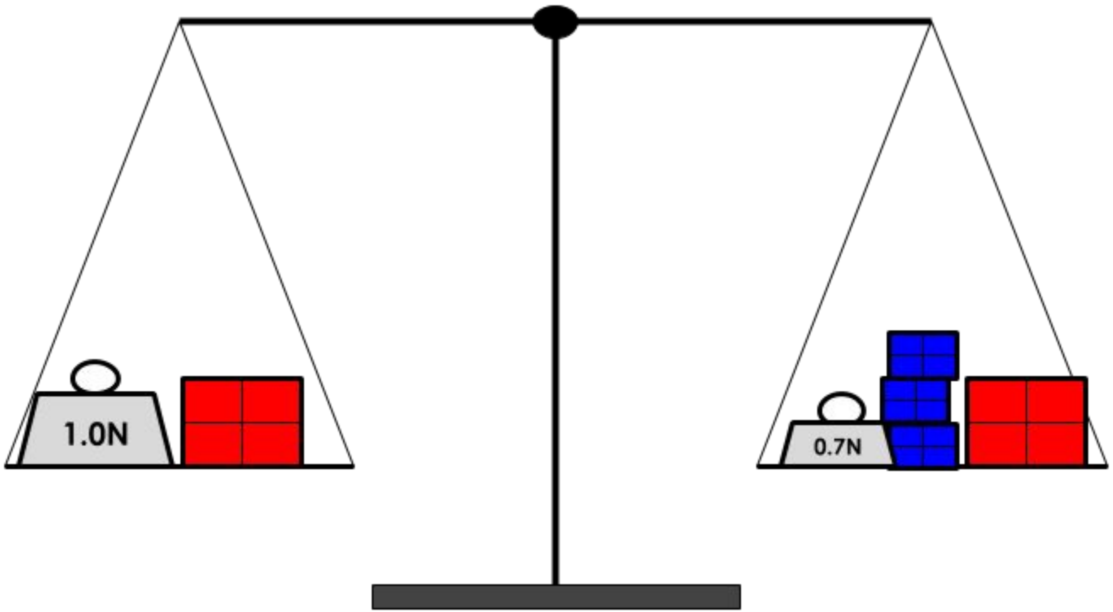
2.625kg - 1.65kg = 0.975kg

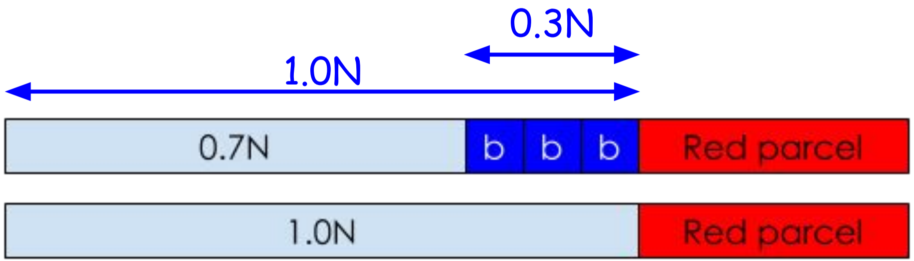
=0.975/3

=0.325kg

KS2 SATs question

Calculate the weight of each small blue parcel.

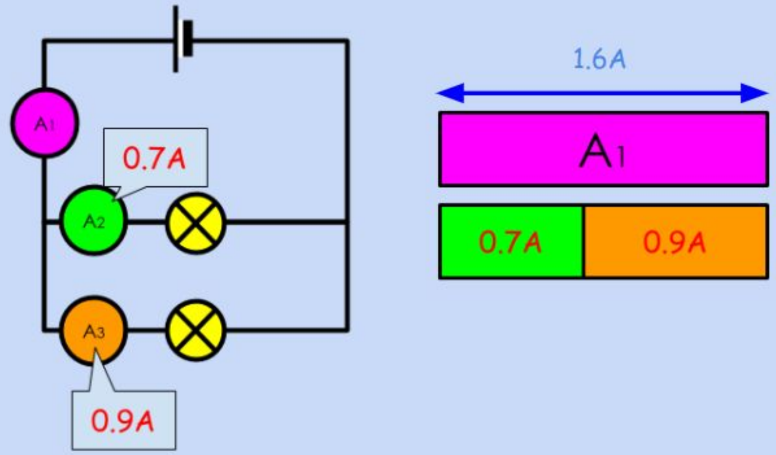




1 blue parcel weighs 0.1N

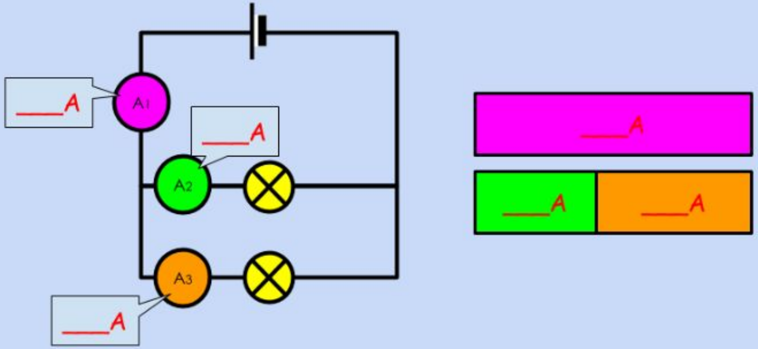
Electricity

I do



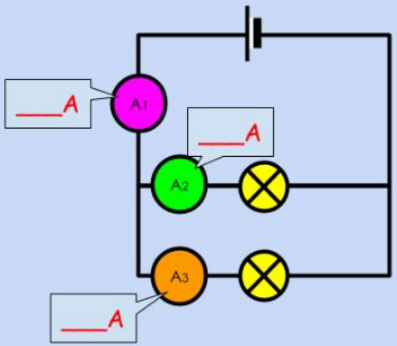
we do

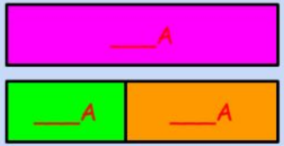
If the current through A_2 is 1.2A and the current through A_3 is 0.8A, what is the current through A_1?



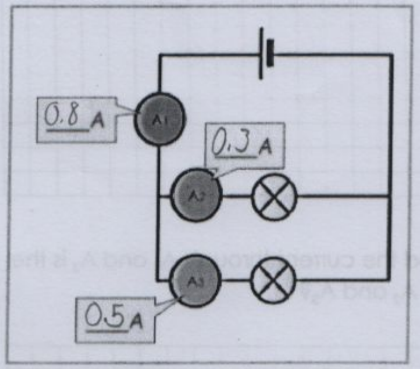
you do

If the current through A_2 is 1.0A and the current through A_3 is 0.9A, what is the current through A_1?





1. If the current through A_2 is 0.3A and the current through A_3 is 0.5A, what is the current through A_1?

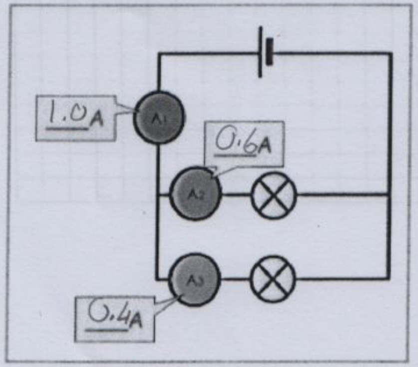


$A_1 = 0.8$
$A_2 = 0.3$
$A_3 = 0.5$

0.8
0.3 | 0.5

(1)

2. If the current through A_1 is 1.0A and the current through A_2 is 0.6A, what is the current through A_3?



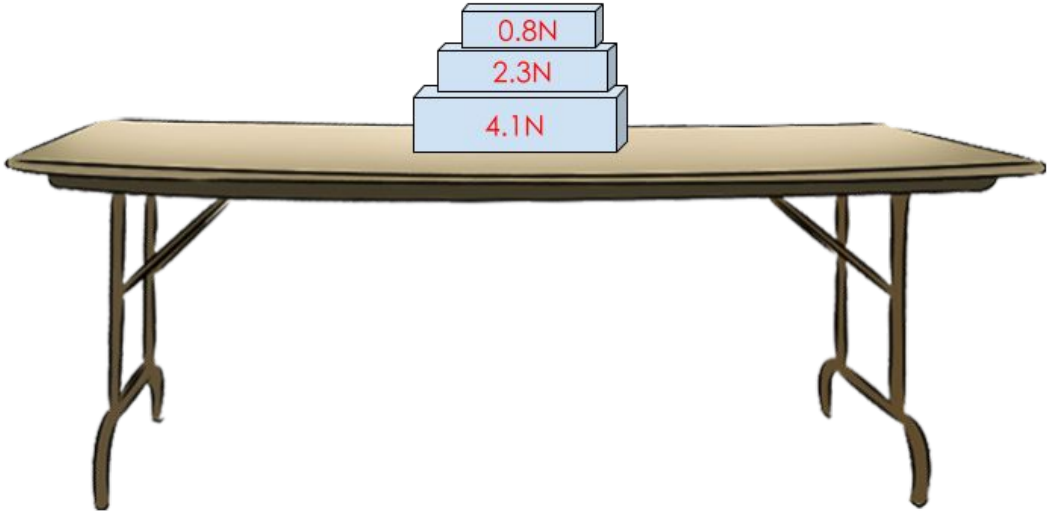
$A_1 = 1.0$
$A_2 = 0.6$
$A_3 = 0.4$

1.0
0.6 | 0.4

(1)

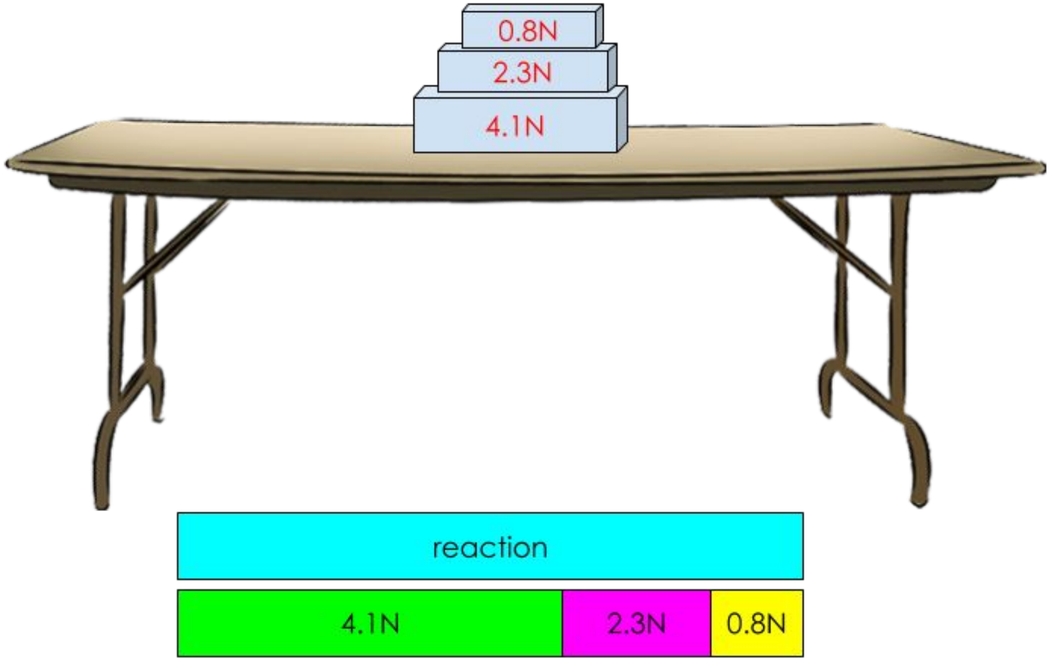
Applications

Calculate the reaction force from the table.



Applications

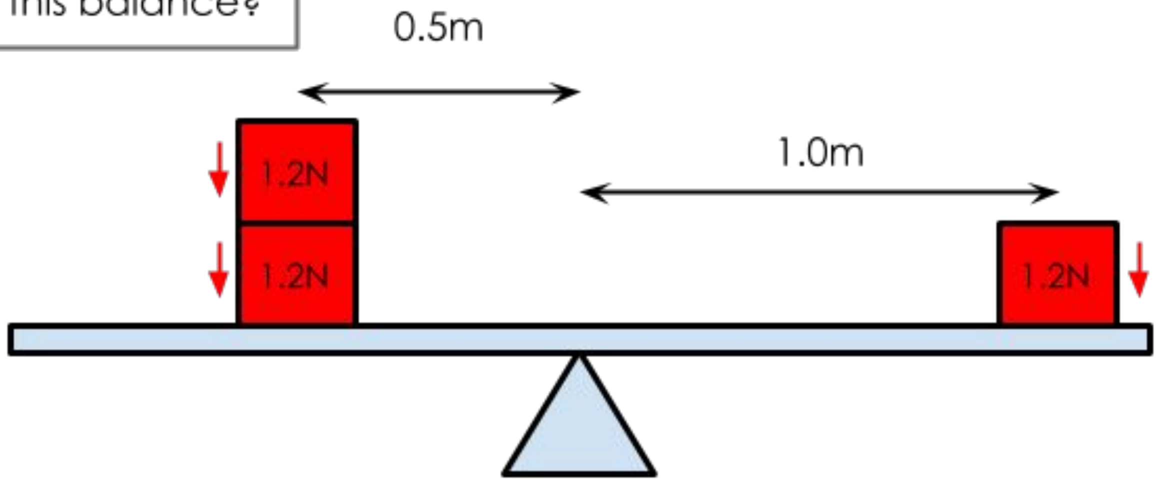
Calculate the reaction force from the table.

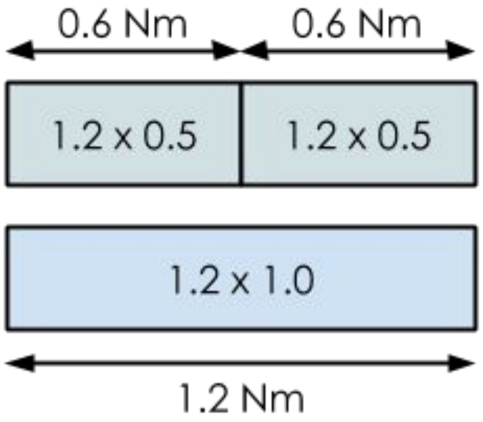


3 friends play tug of war against a teacher. The forces are balanced. The teacher pulls with 600N. One friend pulls with 190N. Another pulls with 290N. How much force does the third friend pull with?

600N		
190N	290N	?

Does this balance?





2 parcels 0.5m from the pivot:
Moment = 2 x (1.2 x 0.5) = 2 x 0.6 = <u>1.2 Nm</u>

1 parcel 1.0m from the pivot:
Moment = 1.2 x 1.0 = <u>1.2 Nm</u>

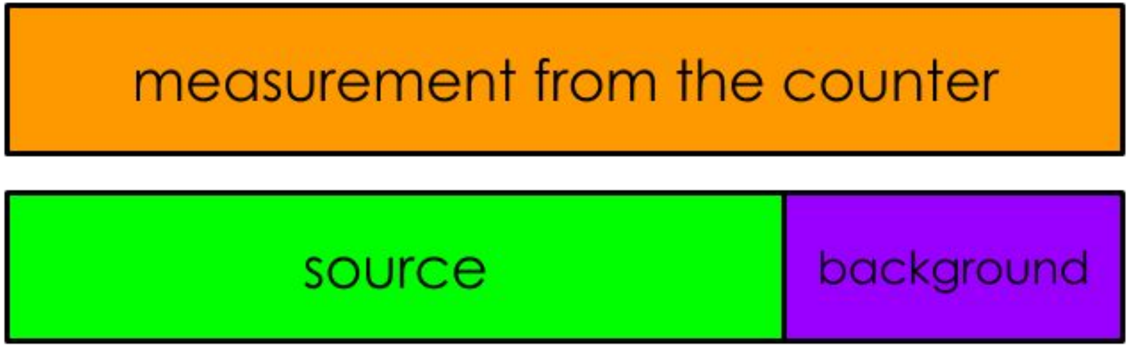
A teacher uses a Geiger-Müller tube and a counter to measure background radiation. The reading on the counter tube is 34 counts per minute.

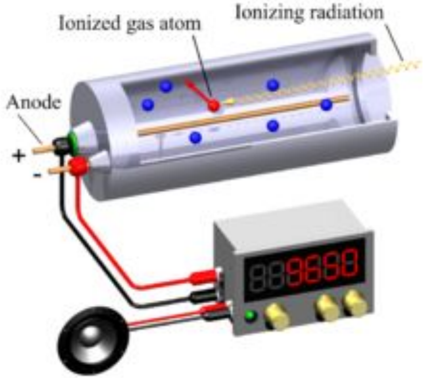
The teacher puts a source of beta radiation 15 cm in front of the same Geiger-Müller tube. The reading on the counter tube is now 468 counts per minute.

Calculate how much radiation detected by the Geiger-Müller tube comes from the source of beta radiation.

[1 mark]

[https://www.bbc.com/education/guides/z2n8h39/revision/2]



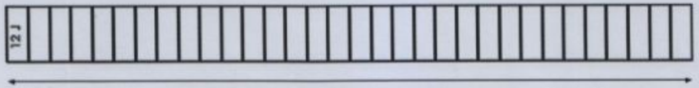


Each second 12J of energy from the Sun reaches each tile.

Calculate the total amount of energy reaching the solar panel in 1 second.

[3]

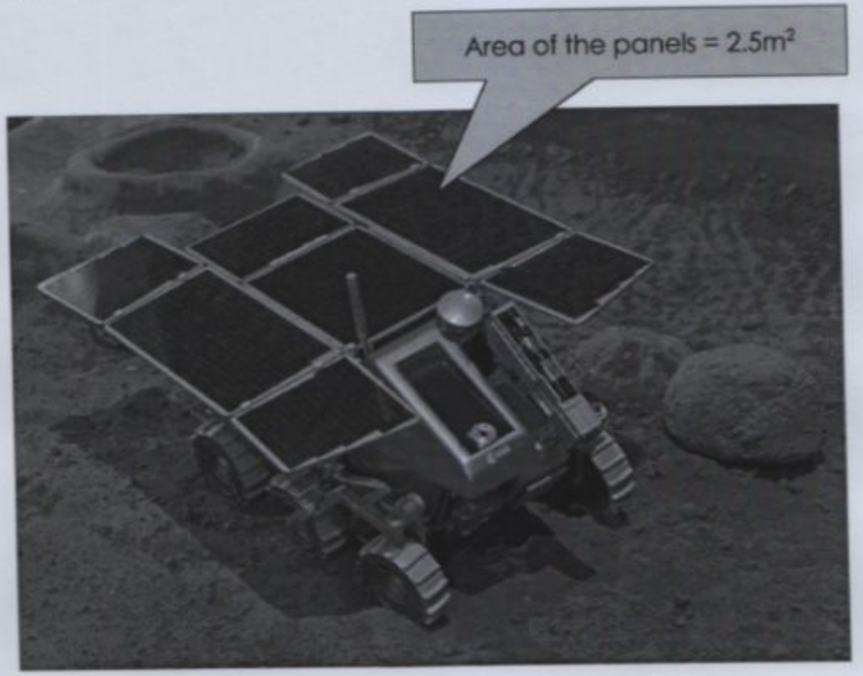
Number of tiles = 4 x 8 = 32



32

32
x12
64
320
384

Energy per second = 384 J



Each second 400J of energy from the Sun reaches $1m^2$ of the solar panel.

Calculate the total amount of energy reaching the solar panel in 1 second.

[3]

400	400	200
$1m^2$	$1m^2$	$0.5m^2$

The total power input to the leaf blower is 750 W.
The useful power output of the leaf blower is 360 W.

Calculate the efficiency of the leaf blower.

Use the correct equation from the Physics Equations Sheet.

[2 marks]

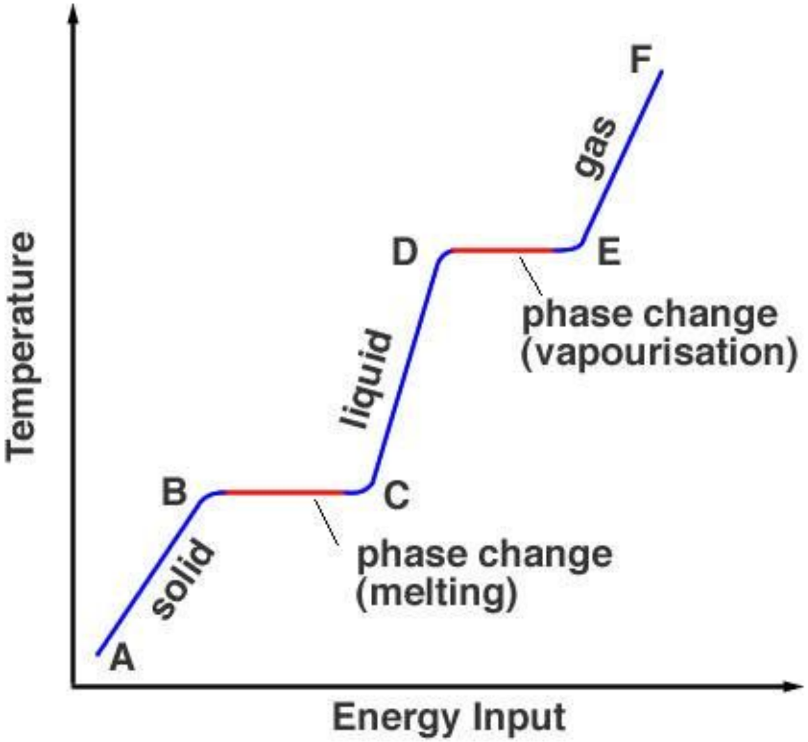
750 W input

360W ?

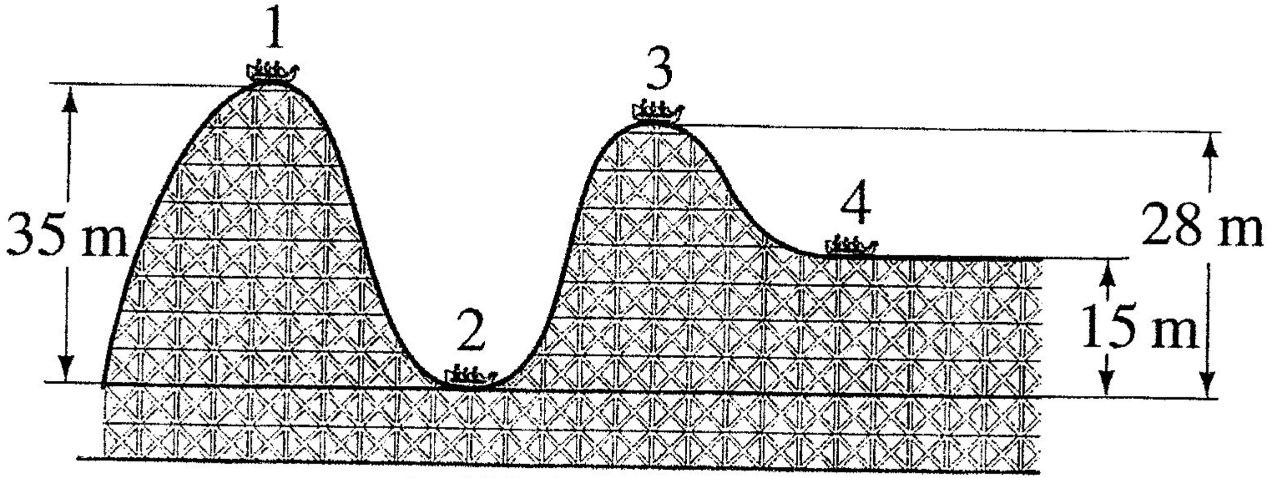
$\frac{360}{750} \times 100\% = 48\%$

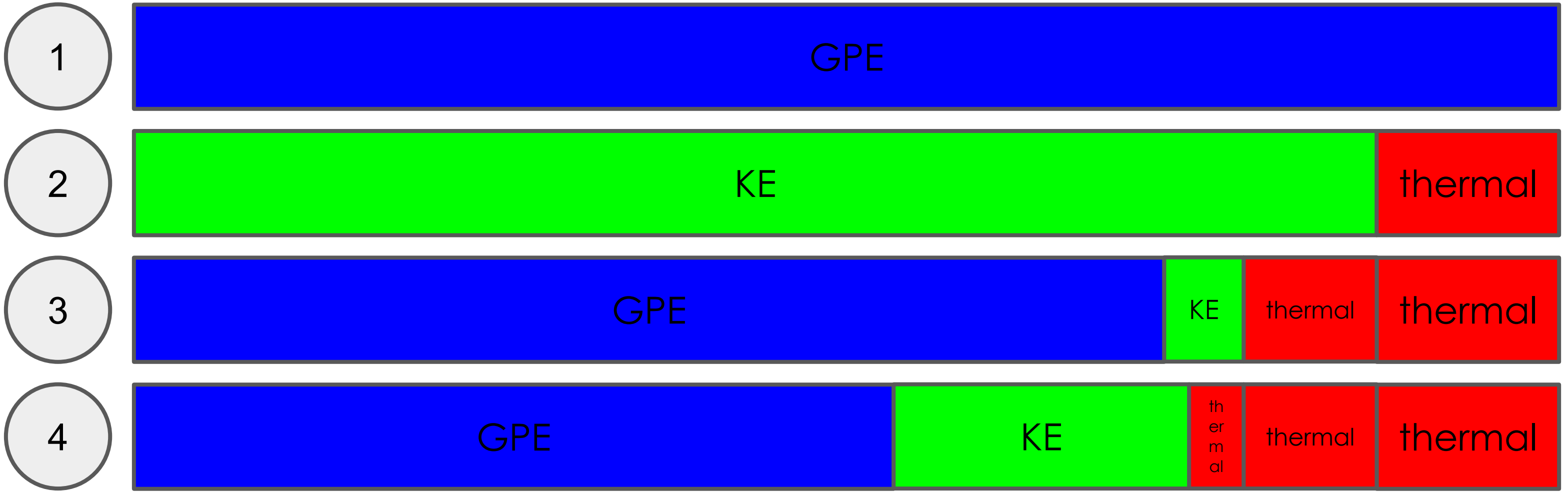
Efficiency = 48%

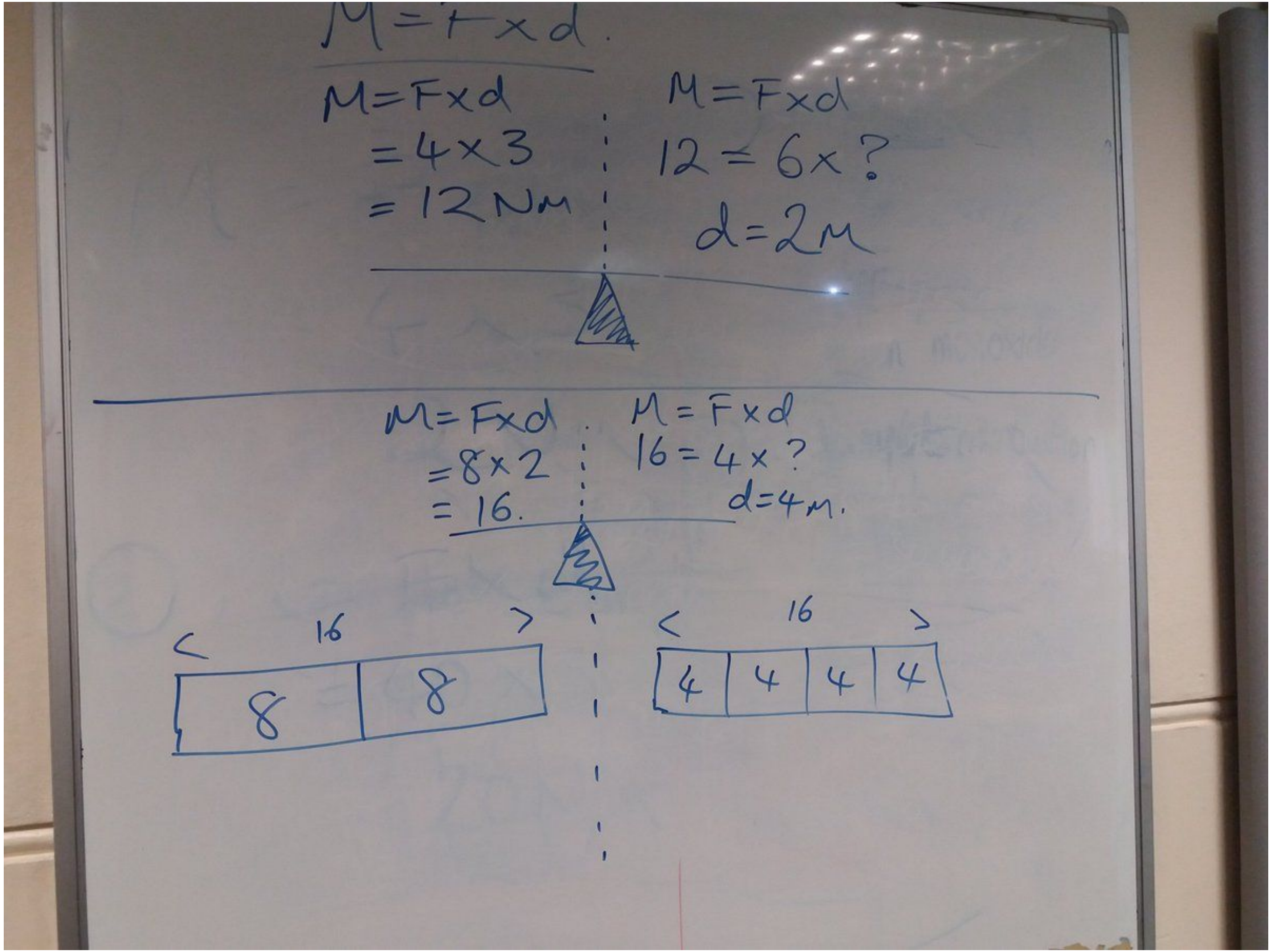
Latent Heat



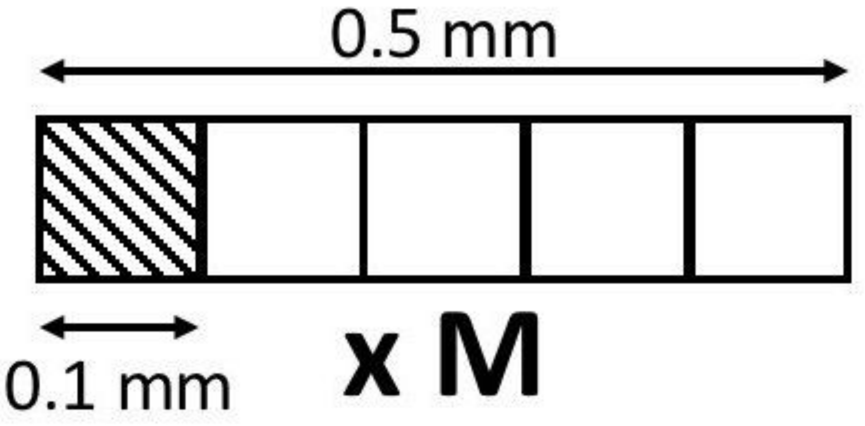
total energy				
A-B	B-C	C-D	D-E	E-F


1
3
4
2
35 m
28 m
15 m


1
GPE
2
KE
thermal
3
GPE
KE
thermal
thermal
4
GPE
KE
thermal
thermal
thermal

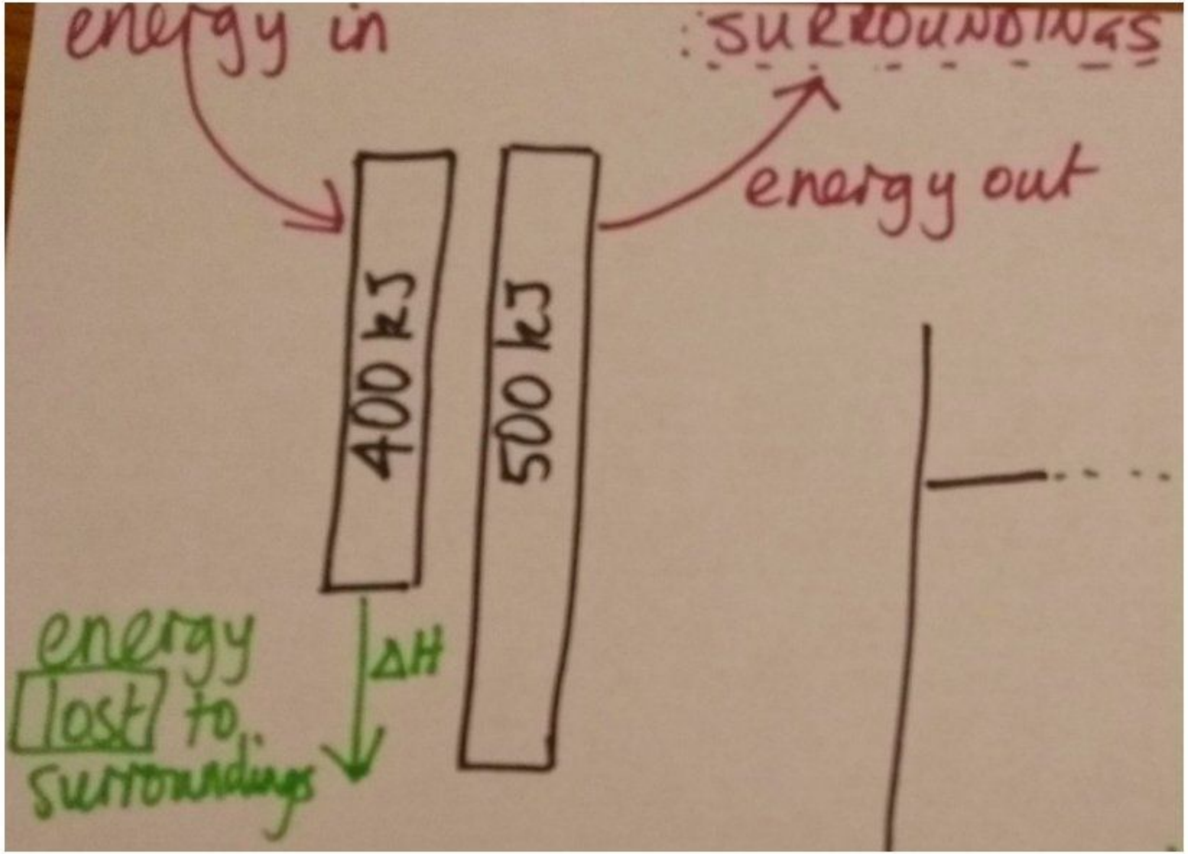

M = F x d
M = F x d
= 4 x 3
= 12 Nm
M = F x d
12 = 6 x ?
d = 2m
M = F x d
= 8 x 2
= 16.
M = F x d
16 = 4 x ?
d = 4m.
16
8
8
16
4
4
4
4


David Paterson
@dave2004b
Follows you



Magnification

Energy, bars and threshold concepts



Niki Kaiser (K Chem)

@chemDrK Follows you

Jenny Koenig @JennyAKoenig · Mar 15

I've used bar models when using ratio and proportion in chemistry - especially dilutions. I agree completely about transferring maths pedagogy into science!

2 2 4

Ben Rogers @BenRogersEdu · Mar 17

Could I take a look at how you did this Jenny? Thanks

1

Jenny Koenig

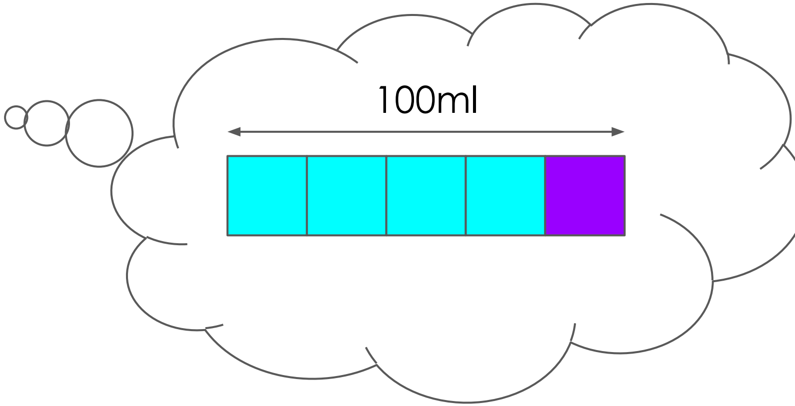
@JennyAKoenig

Following

Replying to @BenRogersEdu @DSGhataura and 2 others

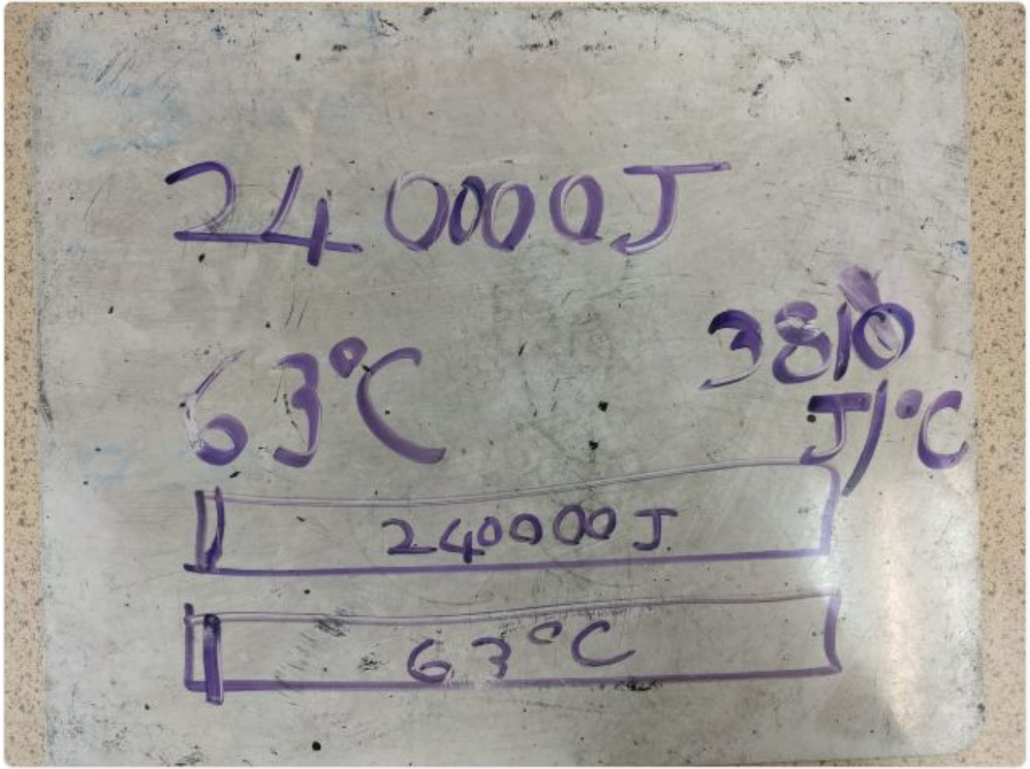
I just sketched diagrams on the board so don't have a handout. In the instructions for diluting ribena it says 1 part to 4 parts water so you can draw that as a bar model then say you want 100ml altogether you can use the bar to work out the volumes.

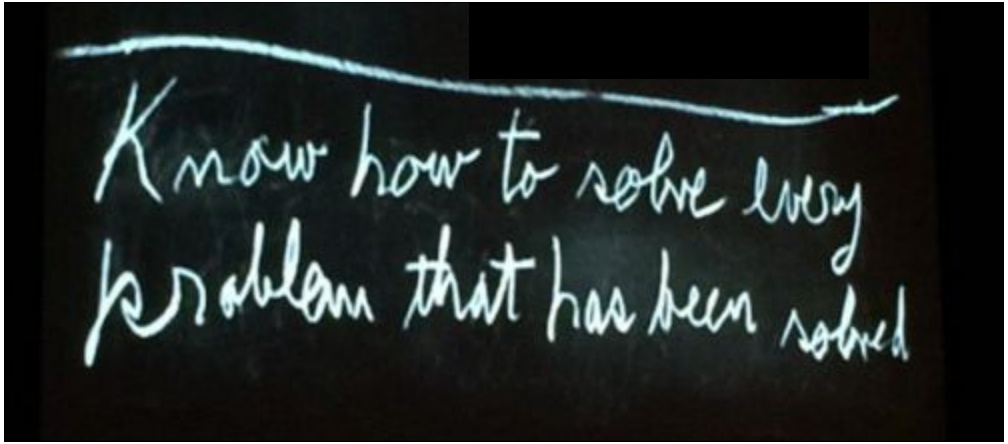
8:17 PM - 18 Mar 2018



Ruth Smith @ruthyie · Apr 27

@BenRogersEdu Heated bubble bath, wanted to find the energy supplied per degC. (teaching SHC drip by drip to Y9) I tried the bar method you write about to groups and they gasped at the notional 1/63 slice stage and knew what to do with 240 000 J. Seems to help #asechat

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Know how to solve every
problem that has been solved

Feynman

A physicist is the sum of the problems she can solve.

Ben Rogers