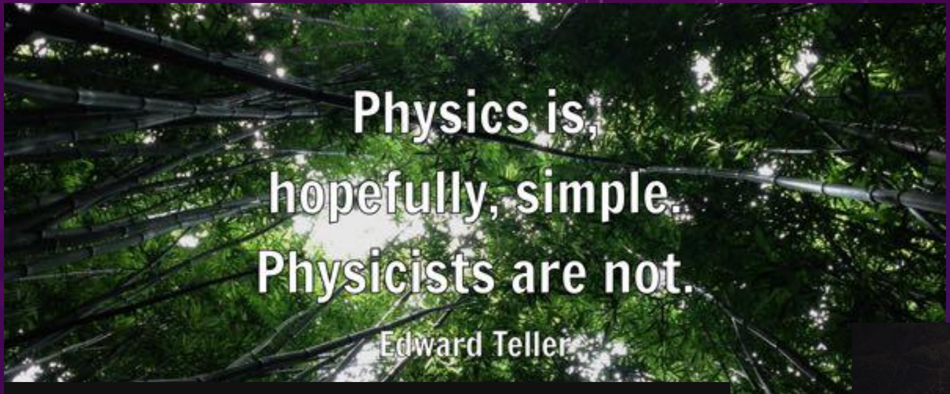
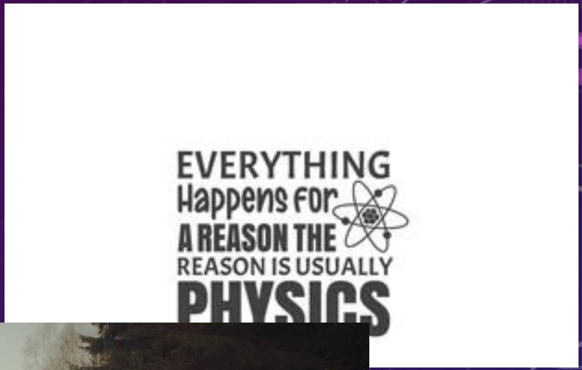
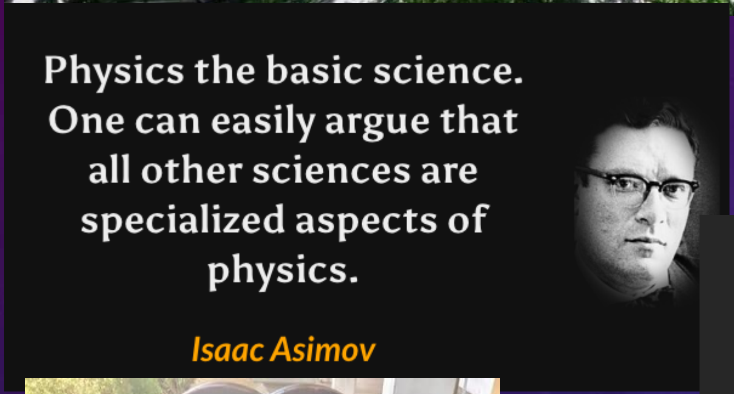
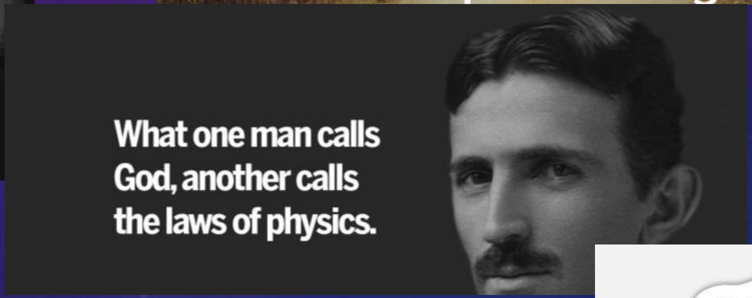
WELCOME TO PHYSICS

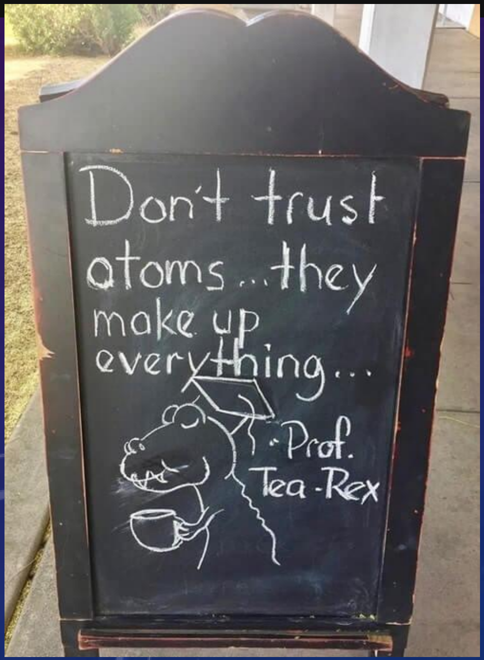

Physics is,
hopefully, simple.
Physicists are not.
Edward Teller

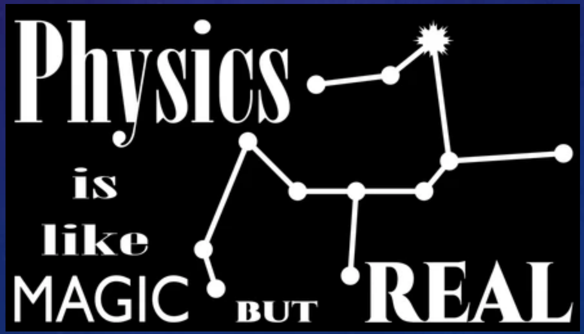

EVERYTHING
Happens for
A REASON THE
REASON IS USUALLY
PHYSICS

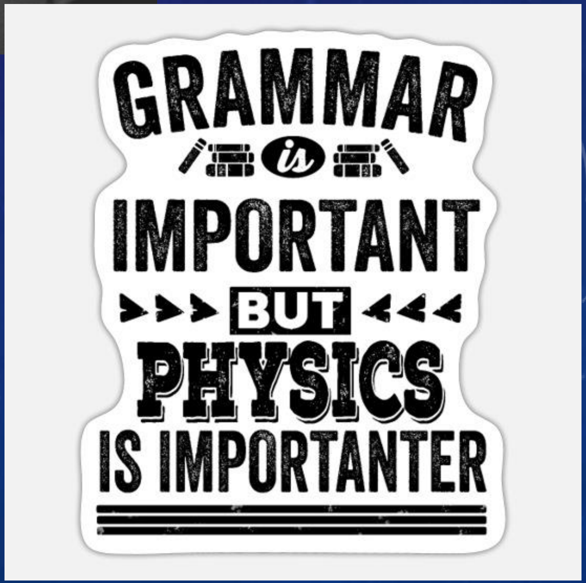

Physics the basic science.
One can easily argue that
all other sciences are
specialized aspects of
physics.
Isaac Asimov


Physics is the only real
science. The rest are just
stamp collecting.


What one man calls
God, another calls
the laws of physics.


Don't trust
atoms...they
make up
everything...
-Prof.
Tea-Rex


Physics
is
like
MAGIC
BUT
REAL

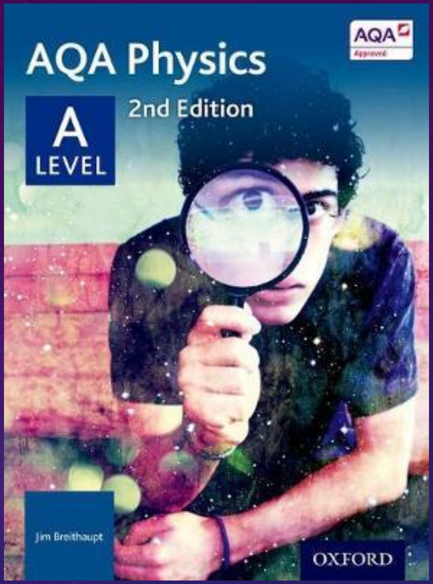

GRAMMAR
is
IMPORTANT
BUT
PHYSICS
IS IMPORTANTER

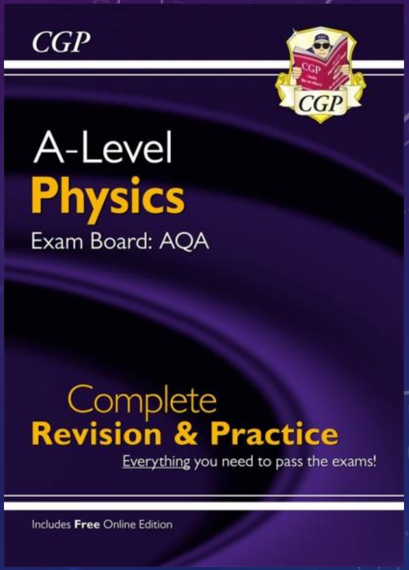
COURSE OUTLINE - Year 1

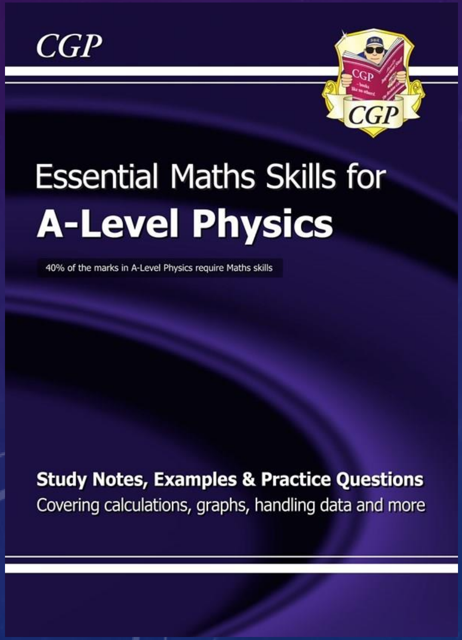
- Induction
- Mr Gill: Particles – Waves – Optics – Optional Unit
- Mrs Steele: Statics – Mechanics – Materials – Electricity

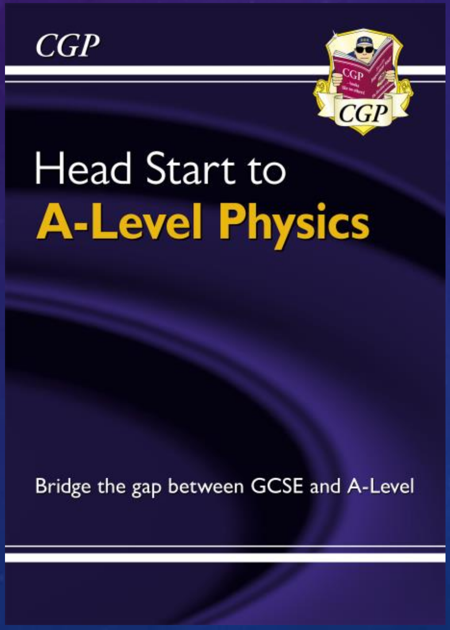
- The optional unit is a choice up to the school and students, there are 5 to pick from: Turning Points in Physics, Engineering Physics, Astrophysics, Electronics, Medical Physics

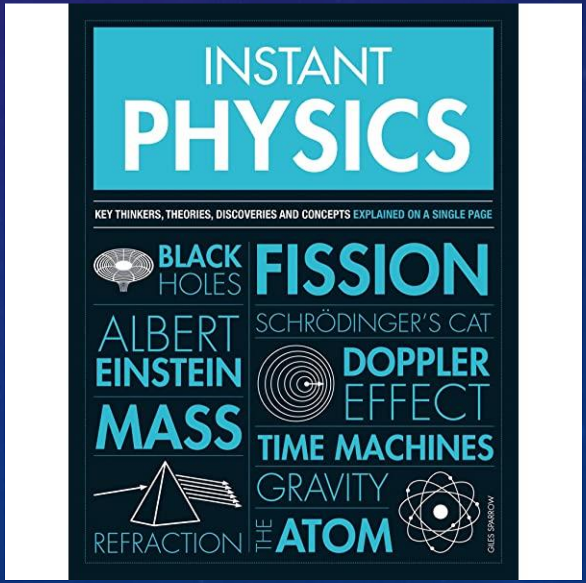
BOOKS – you will be provided with a log in to digitally access the textbook, others are optional and can be borrowed from SC5



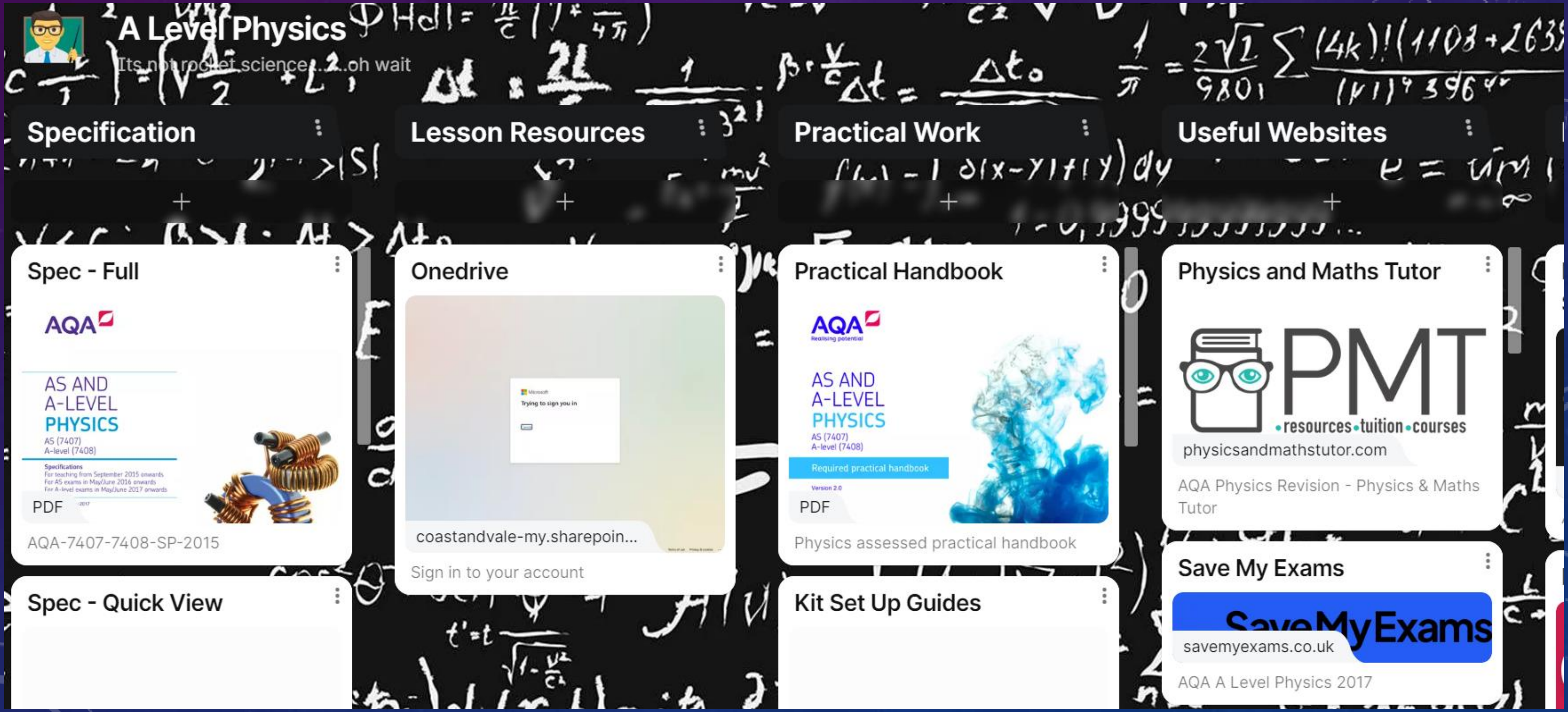








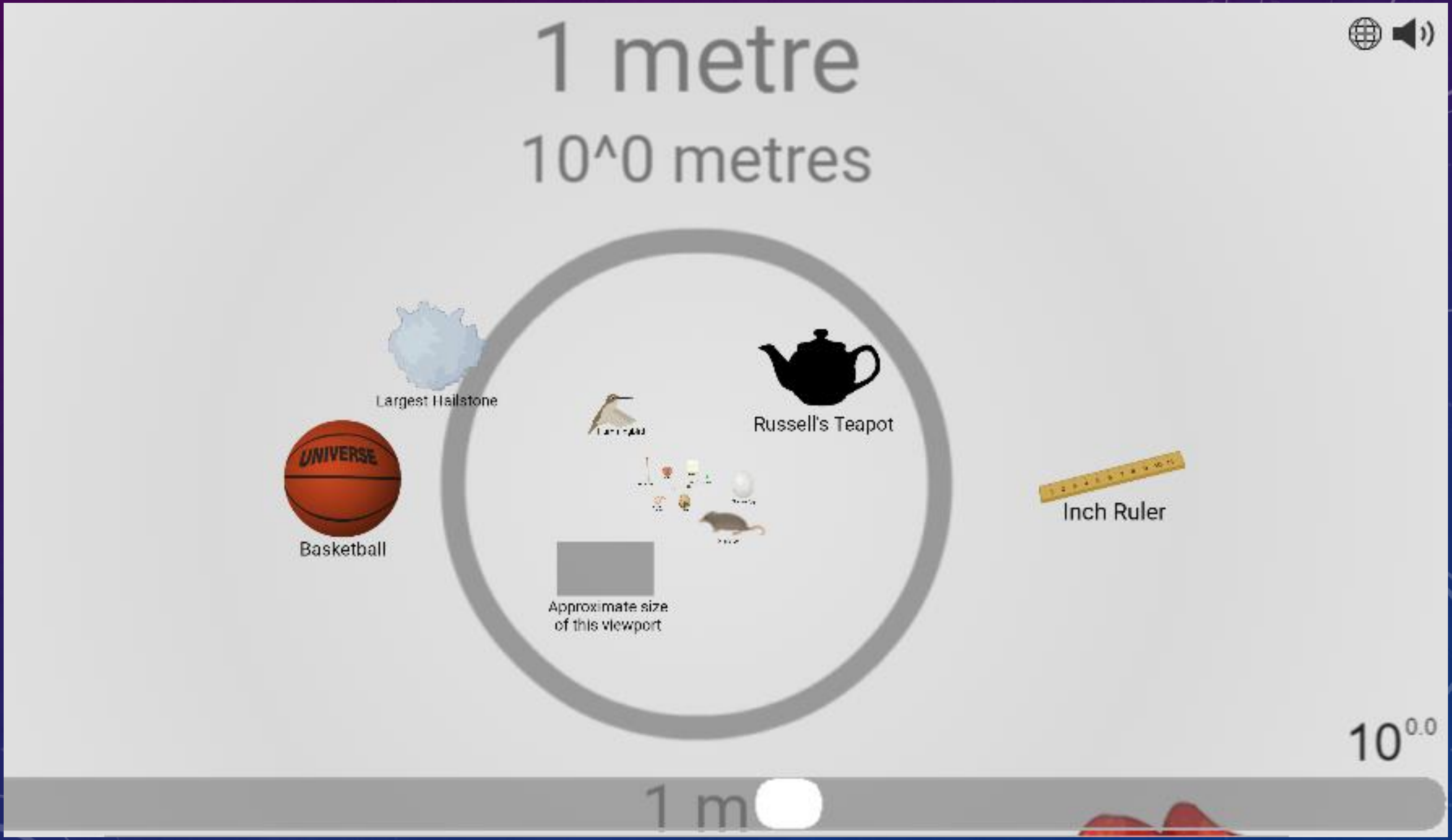
Padlet – a way of accessing course content remotely, if you email Mr Gill over summer you can be added before September



HOW TO SUCCEED!

- Be organised. Use your time effectively and ensure you dedicate enough time to your Physics studies.
- Be engaged and focussed during lessons – take part, talk to your peers, ask questions, think about what's being said, don't be scared of being wrong.
- Complete all set tasks. There is a lot to learn and there are no short cuts.
- Review past content regularly.
- Ask for help when you need it! Mr Gill runs afterschool and in school support sessions!

SCALE OF THE UNIVERSE



POWERS OF TEN

The base ten counting system was developed in India

These can be written as powers of 10:

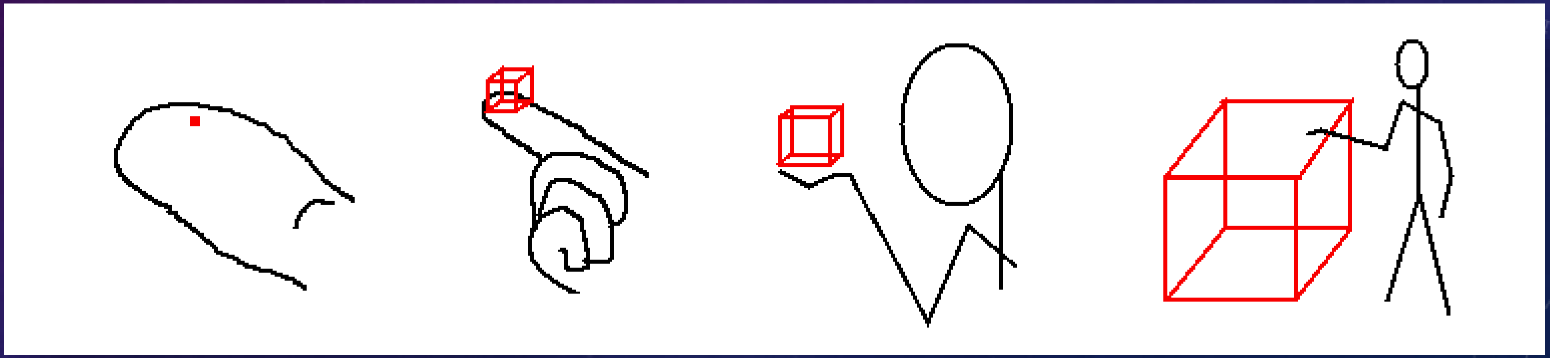
0.001	10^{-3}
0.01	10^{-2}
0.1	10^{-1}
1	10^{0}
10	10^{1}
100	10^{2}
1000	10^{3}

Powers of Ten

10^7	10000000
10^6	1000000
10^5	100000
10^4	10000
10^3	1000
10^2	100
10^1	10
10^0	1
10^{-1}	1/10
10^{-2}	1/100
10^{-3}	1/1000
10^{-4}	1/10000
10^{-5}	1/100000
10^{-6}	1/1000000
10^{-7}	1/10000000

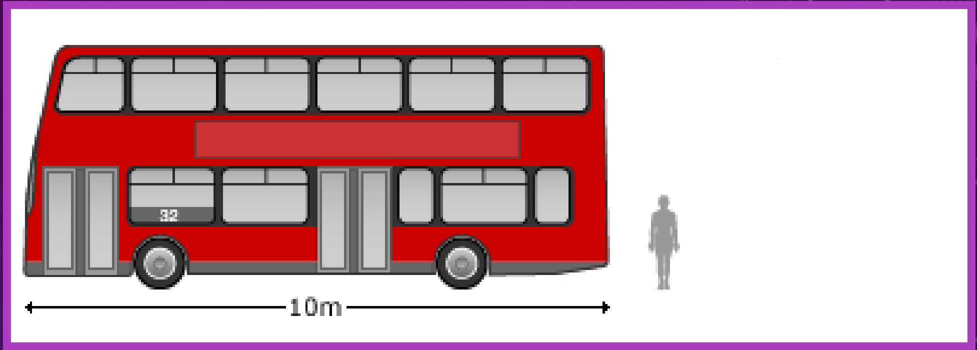
ESTIMATION AND VISUALISATION

- For quantities which we can relate to it often helps to visualise the item:



- Eg. Is something closer to the size of a grain of sand, a marble, a ball, a big box?

VISUALISATION



- As long as a bus, a football pitch, as far as from here to the city centre.

VALUES TO USE

Object	Distance / m
Thickness of a hair	10^{-4}
Grain of Sand	10^{-3}
Marble	10^{-2}
Ball	10^{-1}
Big Box	10^{0}
Bus	10^{1}
Football Pitch	10^{2}
Distance to Winchester City Centre	10^{3}
Distance to the Moon	10^{8}
Distance to the Sun	10^{11}

ESTIMATION EXAMPLE:

How many tennis balls could you fit into Centre Court at Wimbledon?

HOW WE MIGHT DO IT…

Assume Centre Court is a cuboid with the following dimensions:

L = 100 m W = 100 m H = 10 m

Assume a tennis ball is a cube with side length 10 cm.

APPROXIMATE ANSWER TO THE NEAREST ORDER OF MAGNITUDE

Assume Centre Court is a cuboid with the following dimensions:

L = 100 m W = 100 m H = 10 m

Assume a tennis ball is a cube with side length 10 cm.

$N = 1 \times 10^8$

OR MORE PRECISELY…

Assume Centre Court is a cuboid with the following dimensions:

L = 110 m W = 119 m H = 19 m

Assume a tennis ball is a cube with side length 6.6 cm.

ACTUAL ANSWER

Assume Centre Court is a cuboid with the following dimensions:

L = 110 m W = 119 m H = 19 m

Assume a tennis ball is a cube with side length 6.6 cm.

$N = 8.7 \times 10^{8}$

ORDER OF MAGNITUDE CALCULATIONS

Sometimes physics is about calculating quantities with a high degree of precision and accuracy.

However, often we just want to know whether our ideas are plausible or get some indication of what sort of answer to expect.

https://innovativeteachingideas.com/blog/an-excellent-collection-of-fermi-problems-for-your-class

ORDER OF MAGNITUDE CALCULATIONS

Guide estimations.

Check calculations.

Challenge misconceptions

Question 1

How many iPhones would you need to stack flat on top of each other in order to reach the moon?

Question 1

How many iPhones would you need to stack on top of each other in order to reach the moon?

Thickness of iPhone $\approx 1 \times 10^{-2}$m

Distance to the moon$\approx 1 \times 10^{8}$m

Therefore 1×10^{10} iphones

Question 2

How long would it take you to walk to New York from here?

Question 2

How long would it take you to walk to New York from here?

Distance to New York$\approx 9 \times 10^6$m (New York is 5 hours behind us)

Average walking pace$\approx 2\ ms^{-1}$

Therefore time taken $\frac{9\times10^6}{2} = 5 \times 10^6 s \approx 2 months$

Question 3

How many words are there in the physics text book?

Question 3

How many words are there in your physics text book?

Number of pages ≈ 300

Number of lines per page ≈ 40

Number of words per line ≈ 10

Therefore number of words $\approx 300 \times 40 \times 10 = 120000 \approx 1 \times 10^5 words$

Question 4

What is the total mass of the human population of the earth?

Question 4

What is the total mass of the human population of the earth?

Human population$\approx 7 \times 10^9$people

Average mass of a person$\approx 60kg$

Therefore mass of world population$\approx 42 \times 10^{10}kg \approx 4 \times 10^{11}kg$

Question 5

How many water molecules are there in a typical glass of water?

Question 5

How many water molecules are there in a typical glass of water?

Volume of glass about half a litre

Mass of water in half a litre is 0.5kg

Mass of one mole of water is 18g

Therefore there are $\frac{500}{18} = 28\ moles = 1.7 \times 10^{25} molecules \approx 2 \times 10^{25}$

$(2 \times 10^{21}\ glasses\ of\ water\ in\ all\ the\ oceans)$

Question 6

How long would it take to drive to the nearest star in a standard family car?

Question 6

How long would it take to drive to the nearest star in a standard family car?

Nearest star is about 4 light years away $\approx 4 \times 10^{16}\ m$

(Name of the nearest star is proxima centauri which translates as nearest star)

A family car can cruise at 70mph $\approx 40\ ms^{-1}$

Therefore time needed $\approx \frac{4\times10^{16}}{40} = 1 \times 10^{15} s \approx 30\ million\ years$

USING POWERS OF 10

$$10^x \times 10^y = 10^{x+y}$$

$$10^2 \times 10^3 = 10^5$$

$$\frac{10^x}{10^y} = 10^{x-y}$$

$$\frac{10^5}{10^3} = 10^2$$

$$\frac{1}{10^x} = 10^{-x}$$

$$\frac{1}{10^4} = 10^{-4}$$

$$\frac{1}{10^{-x}} = 10^x$$

$$\frac{1}{10^{-4}} = 10^4$$

MULTIPLYING AND DIVIDING POWERS OF TEN

When multiplying powers of ten we add the indices:

- $10^3 \times 10^5 =$
- $10^{-3} \times 10^7 =$
-

When dividing powers of ten we subtract the indices:

- $\frac{10^6}{10^2} =$
- $\frac{10^{-5}}{10^{-3}} =$

MULTIPLYING AND DIVIDING POWERS OF TEN

When multiplying powers of ten we add the indices:

- $10^3 \times 10^5 = 10^{3+5} = \mathbf{10^8}$
- $10^{-3} \times 10^7 = 10^{-3+7} = \mathbf{10^4}$
-

When dividing powers of ten we subtract the indices:

- $\frac{10^6}{10^2} = 10^{6-2} = \mathbf{10^4}$
- $\frac{10^{-5}}{10^{-3}} = 10^{-5+3} = \mathbf{10^{-2}}$

RAISING A POWER TO A POWER

When raising a power to another power we multiply the indices:

-
- $(3^2)^4 =$
- $(5^{-4})^3 =$

RAISING A POWER TO A POWER

When raising a power to another power we multiply the indices:

-
- $(3^2)^4 = 3^{2\times4} = \mathbf{3^8}$
- $(5^{-4})^3 = 5^{-4\times3} = \mathbf{5^{-12}}$

USING POWERS OF 10 *questions*

Express the following numbers using an appropriate power of 10:

ANSWERS:

1) 5.213×10^{3}
1) 5,213 =

2) 7.32×10^{4}
2) 73,200 =

3) 2.321×10^{1}
3) 23.21 =

4) 2.1×10^{10}
4) 21,000,000,000 =

5) 4.713×10^{9}
5) 4,713,000,000 =

6) 2×10^{-2}
6) 0.02 =

7) 3.14×10^{-4}
7) 0.000314 =

8) 4.3791×10^{-10}
8) 0.00000000043791=

$$1.5 \times 10^{6}$$

$$3.0 \times 10^{4}$$

$$1.9 \times 10^{-14}$$

$$1.2 \times 10^{1}$$

$$9.8 \times 10^{14}$$

Unit prefixes

10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

QUIZLET - PREFIXES

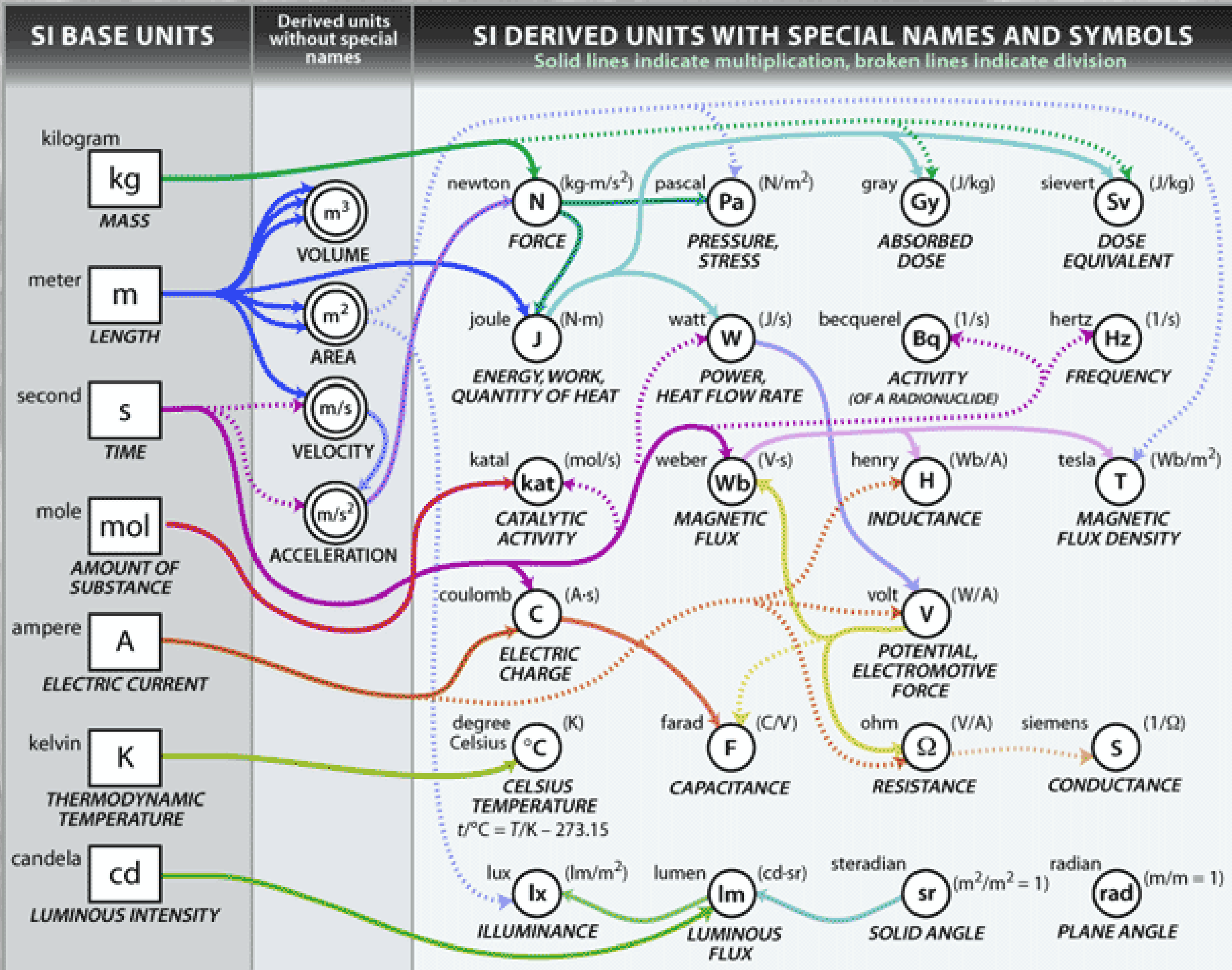
https://quizlet.com/_6iknr7?x=1jqt&i=1p5324

The ENG button

Base Units

Quantity	Unit
Time	second, s
Length	metre, m
Mass	kilogram, kg
Current	Ampere, A
Thermodynamic Temperature	Kelvin, K
Light intensity	Candela, cd,
Amount of substance	mole,mol.

Derived units



The metre is defined by taking the fixed numerical value of the speed of light in vacuum c to be 299 792 458 when expressed in the unit ms^{-1}, where the second is defined in terms of the caesium frequency Δv.

The wording of the definition was updated in 2019.

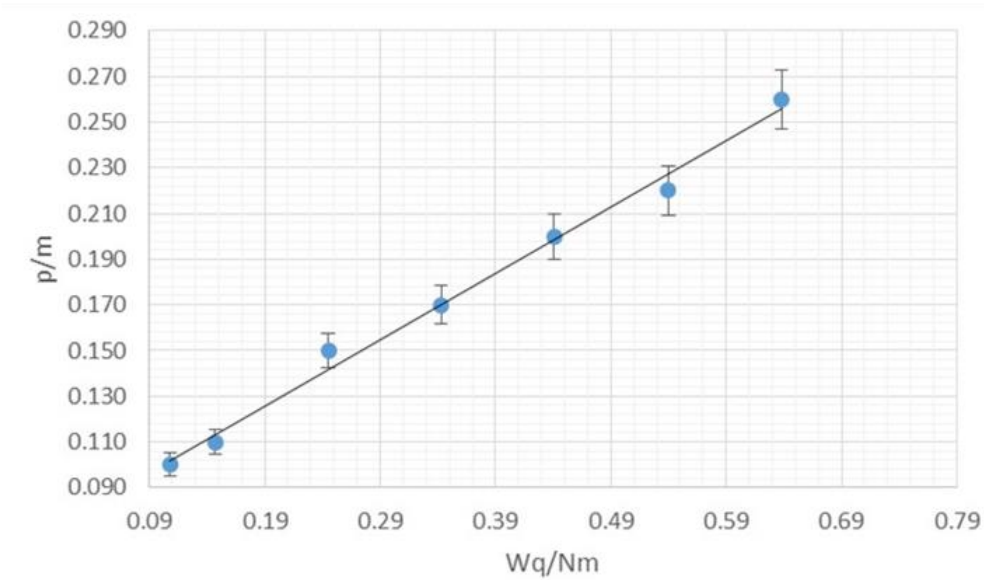
The second is defined by taking the fixed numerical value of the caesium frequency Δv, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}.

The wording of the definition was updated in 2019.

The kilogram is defined by taking the fixed numerical value of the Planck constant h to be $6.626\ 070\ 15 \times 10^{-34}$ when expressed in the unit J s, which is equal to kg m2 s^{-1}, where the metre and the second are defined in terms of c and Δv.

This was a new definition in May 2019.

Measurements and Errors



Random errors affect each result by a different amount.

They cause scatter of data points around the LOBF and affect both the gradient and intercept.

Performing repeats and finding an average reduces the effect of random errors.

Examples:

Human reaction time.

Fluctuations in output from a power supply.

Fluctuations in activity of a radioactive source.

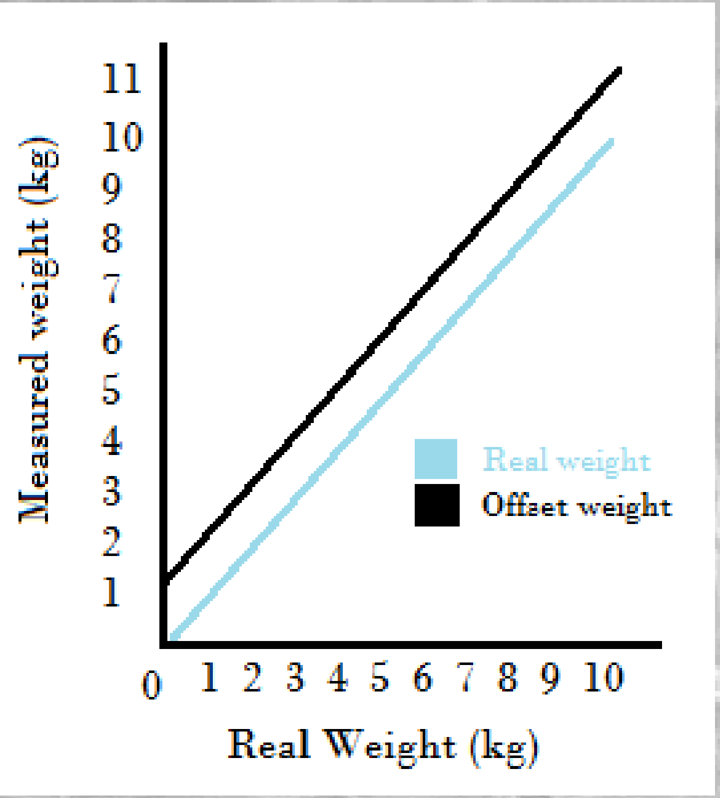
Systematic vs Random Errors

Systematic vs Random Errors

Systematic errors affect all of the results in the same way.

Performing repeats and finding an average does not reduce the effect of systematic errors.

They effect the intercept (but usually not the gradient of a line).

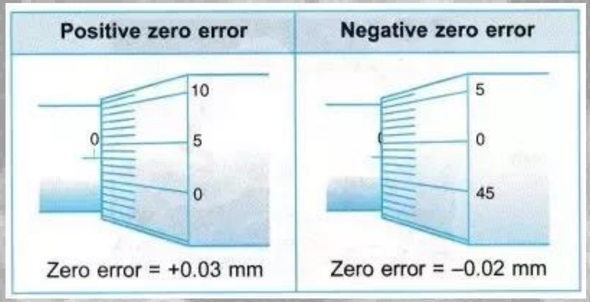


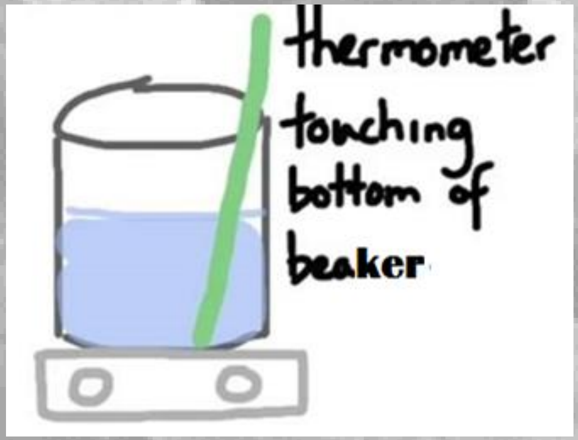
Examples:

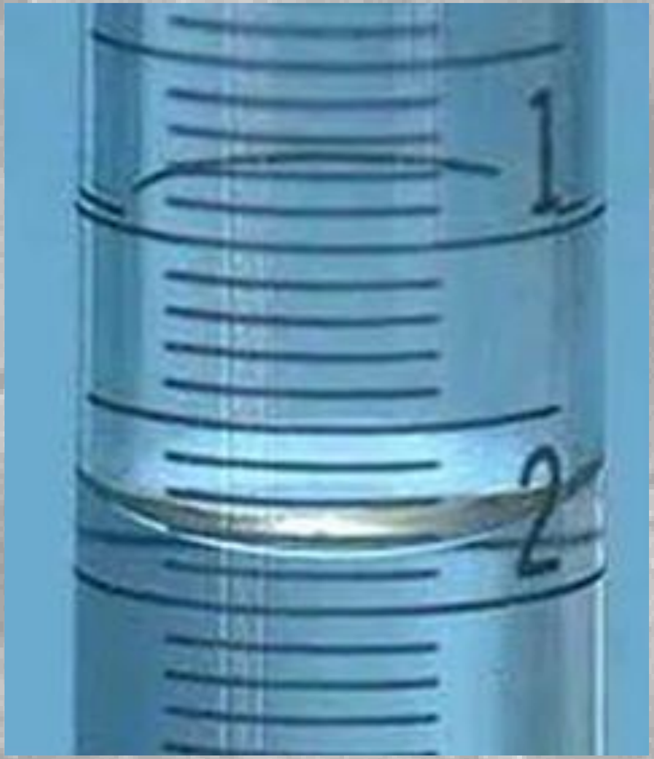
- Zero error.
- Response time of a measuring instrument (if time is a variable).
- Contact resistances in a circuit.
- Wrong interrupt card length entered.

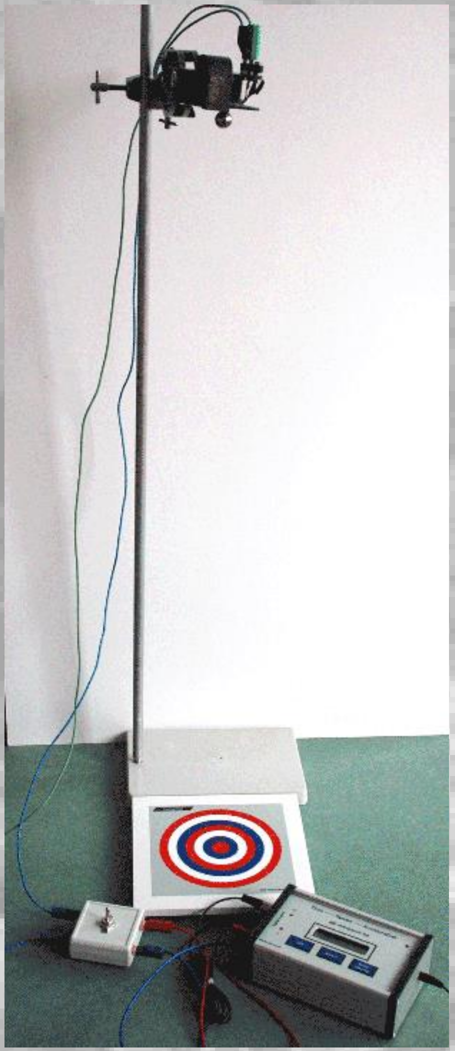
Systematic vs Random Errors

Systematic errors affect all of the results in the same way.

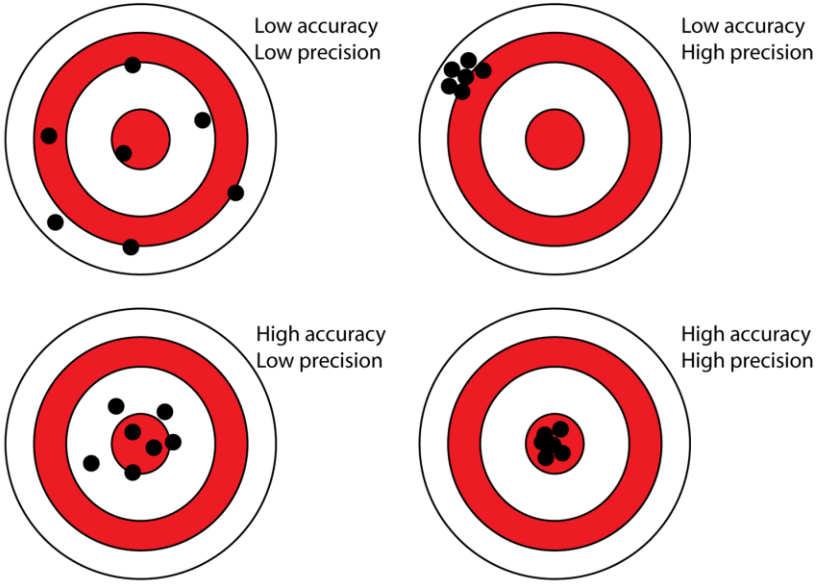






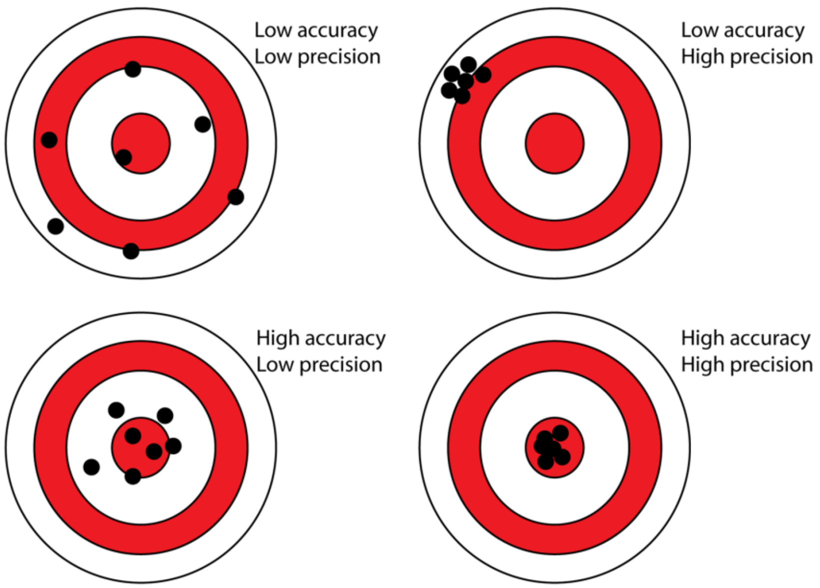


Precision & Accuracy



Precision of a **measurement** is a measure of how closely spaced repeat readings are.

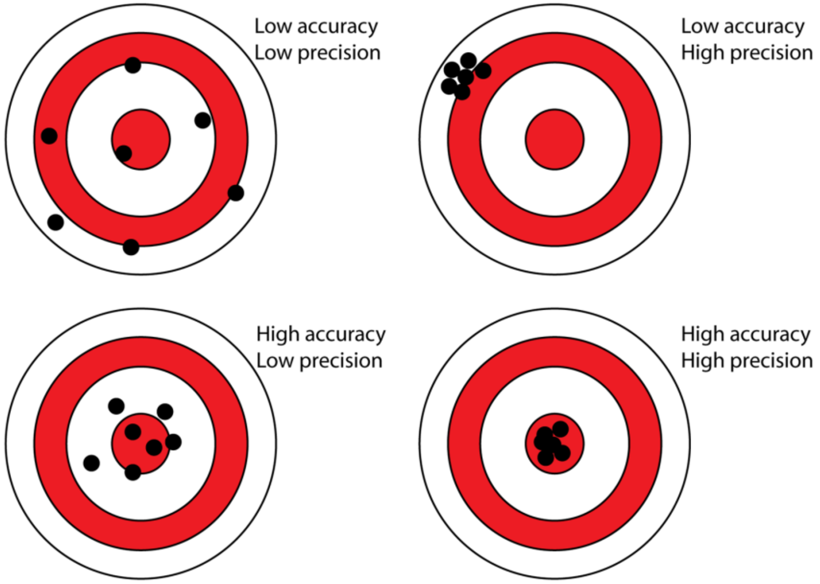
It mainly depends on the size of **random errors** in the measurement.



Precision & Accuracy

Accuracy is a measure of how close a measurement is to the ‘true’ or accepted value.

Accuracy depends on both the **random** and **systematic errors** in an experiment



It is hard to know how accurate a measurement is and it is usually expressed as an uncertainty in the measured value.

Uncertainties are estimated to try and ensure the true value is within our range of uncertainties.

Precision & Accuracy

Accuracy, error and uncertainties

Obtaining an accurate result relies on minimising the errors in our results, this should result in small uncertainties.

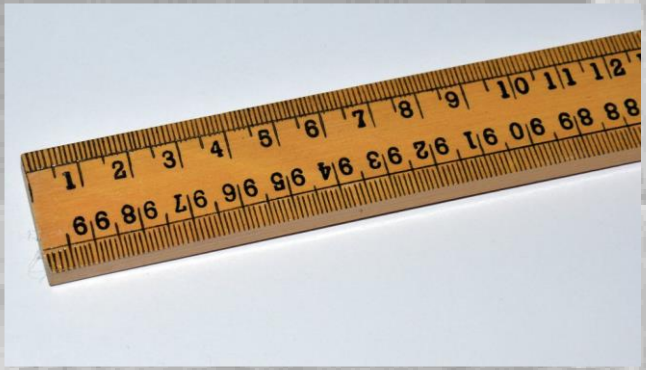
We always prioritise improving those measurements with the greatest % uncertainty.

We can do this by:

- Avoiding all sources of experimental error through our choice of equipment and procedure.
- Repeating results and taking an average.
- Using more precise measuring equipment.
- Making the measured quantities as large as possible.

We will be revisiting all of these as we complete practical work and you will be expected to describe such techniques in exams.

Resolution



Resolution of an instrument is the smallest change in the quantity being measured that can be detected by the instrument.

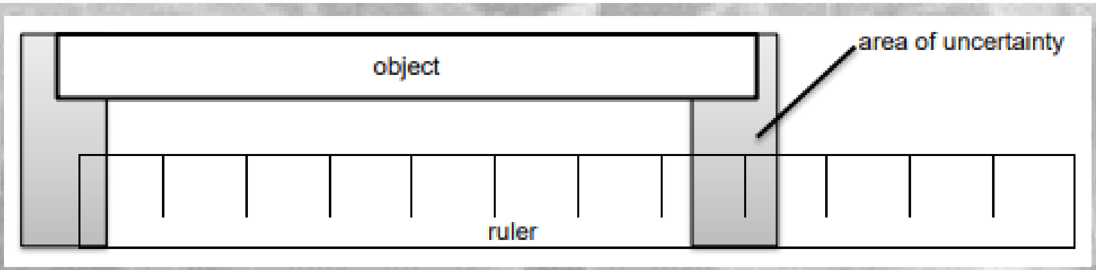
- Resolution of a metre rule = 1mm
- Resolution of Vernier callipers = 0.1mm
- Resolution of the balance is 0.01 g

Absolute Uncertainties

For measurements:

Minimum uncertainty = ± the resolution of the instrument

Reading (one judgement only)	Measurement (two judgements required)
thermometer	ruler
top pan balance	vernier calliper
measuring cylinder	micrometer
digital voltmeter	protractor
Geiger counter	stopwatch
pressure gauge	analogue meter



Repeated readings

If there are repeated reading the uncertainty is usually given as ± ½ the range of repeats after removing any outliers.

For example:

Repeat	1	2	3	4
Distance/m	1.23	1.32	1.27	1.22

1.32 – 1.22 = 0.10 therefore

Mean distance: (1.26 ± 0.05) m

Stated values

If a value is stated without any indication of how it was measured the uncertainty is ± the last decimal place.

e.g. If you are told a distance between two places is 6.3 km the uncertainty would be ± 0.1 km

Sig figs and decimal places.

Uncertainties are usually given to one significant figure and the decimal places in the value should match the dp in the uncertainty.

e.g. 5.376 ± 0.053 ms^{-1} should be written 5.38 ± 0.05 ms^{-1}

Relative and % Uncertainties

- Relative uncertainties state an uncertainty as a proportion or % of the measured quantity.
- Very useful for comparing how significant different sources of error are to a final result.

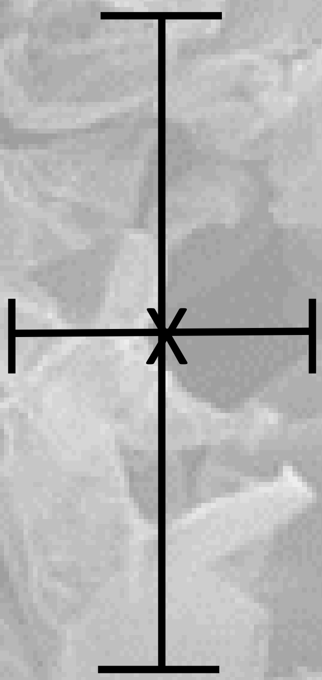
$$Relative\ uncertainty = \frac{Absolute\ uncertainty}{Measured\ OR\ calculated\ value}$$

$$Percentage\ uncertainty = Relative\ uncertainty \times 100$$

Combining uncertainties

Operation	Uncertainty
Multiplication by a constant	% uncertainties are unaffected, absolute uncertainties are multiplied by the constant.
+ OR -	Absolute uncertainties are added
x OR ÷	% uncertainties are added
Quantity raised to a power (including fractional powers e.g. square roots)	Multiply the % uncertainty by the power.

Plotting Error Bars



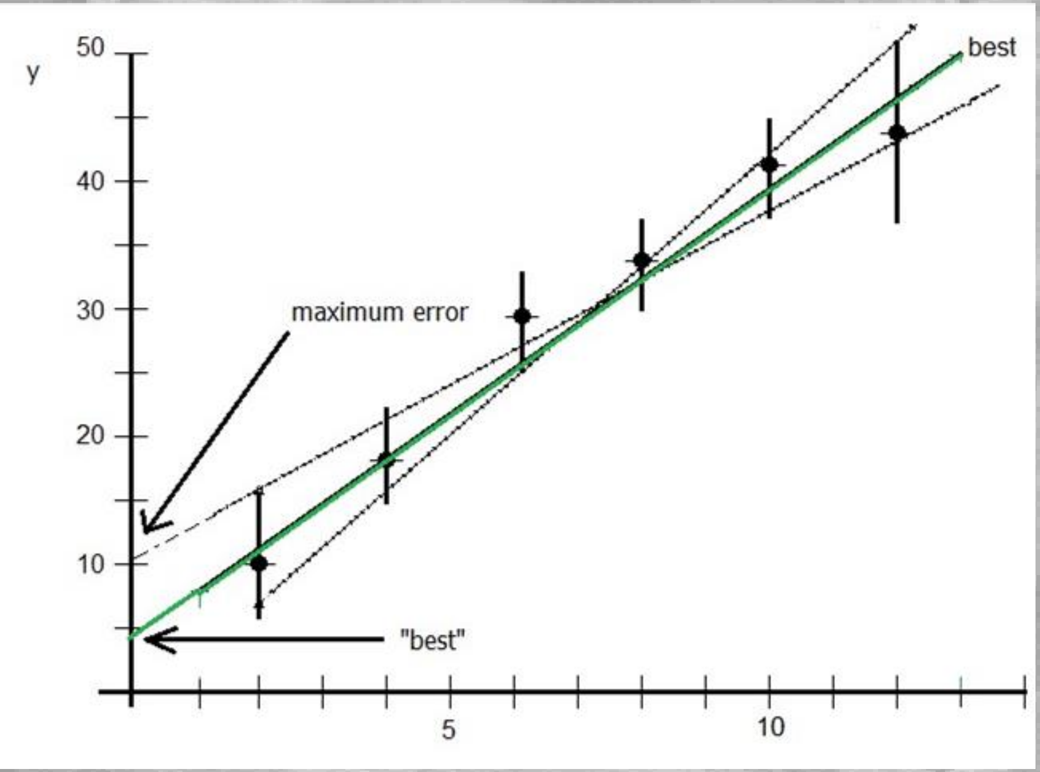
Error bars are used on a graph to represent the uncertainty in a measurement.

The horizontal bar represents the uncertainty in the measurement of the x-variable.

The vertical bar represents the uncertainty in the measurement of the y-variable.

The length of the bar from the data point is equal to the uncertainty in the measurement.

Error bars and lines of worst fit



- We can use error bars to plot lines of worst fit (LOWF).
- From this we can calculate the absolute uncertainty in our gradient and y-intercept values.

$$\Delta m = \pm(m_{best} - m_{worst})$$

$$\Delta c = \pm(c_{best} - c_{worst})$$

The importance of uncertainties

Why didn't they discover the new number was higher right away? When people got a result too high above Millikan's, they thought something must be wrong—and they would look for and find a reason why something might be wrong. When they got a number close to Millikan's value they didn't look so hard. And so they eliminated the numbers that were too far off."

Paraphrased from Richard Feynman