Paper 3 Section A (Practical)

Some of the AS notes are relevant to the practical paper. These are given below.

3.1 Measurements and their errors.

3.1.1 use of SI units and their prefixes

Content

- Fundamental (base) units.
- Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units.
- SI units derived.
- Knowledge and use of the SI prefixes, values and standard form.
- The fundamental unit of light intensity, the candela, is excluded.
- Students are not expected to recall definitions of the fundamental quantities.
- Dimensional analysis is not required.
- Students should be able to use the prefixes: t, g, m, k, c, m, μ, n, p, f.
- Students should be able to convert between different units of the same quantity, e.g. J and eV, J and kWh.

The fundamental base units are as follows:

The ampere (A) for electrical current, the candela (cd) for luminous intensity, the kelvin (K) for thermodynamic temperature, the kilogram (kg) for mass, the metre (m) for length, the mole (mol) for amount of a substance, the second (s) for time.

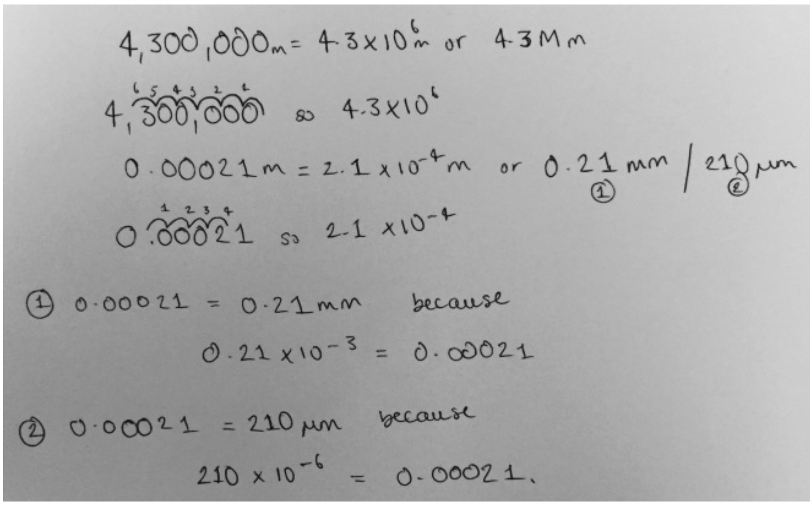
Examples of deriving SI units from other units are:

Joule = $kg.m^2.s^{-2}$, watt= $kg.m^2.s^{-3}$. These units can be derived from equations i.e. From the equation p=fv, where the unit of power is the newton. F=ma so F=$kg.m.s^{-2}$, so $kg.m.s^{-2}$ multiplied by ms^{-1} (which is the "v" from p=fv) equals $kg.m^2.s^{-3}$. So these are the derives SI units of power which has the unit of the watt.

SI prefixes, values and standard form.

Value	Prefix	Symbol
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

Above is a table of the SI prefixes and values, with their respective symbols. The symbols can be used in place of using standard form, however sometimes you will be required to use standard form, which can be done as follows…



$4{,}300{,}000\,m = 4.3 \times 10^{6}\,m$ or $4.3\,Mm$

$4{,}300{,}000$ so 4.3×10^{6}

$0.00021\,m = 2.1 \times 10^{-4}\,m$ or $0.21\,mm$ (1) / $210\,\mu m$ (2)

0.00021 so 2.1×10^{-4}

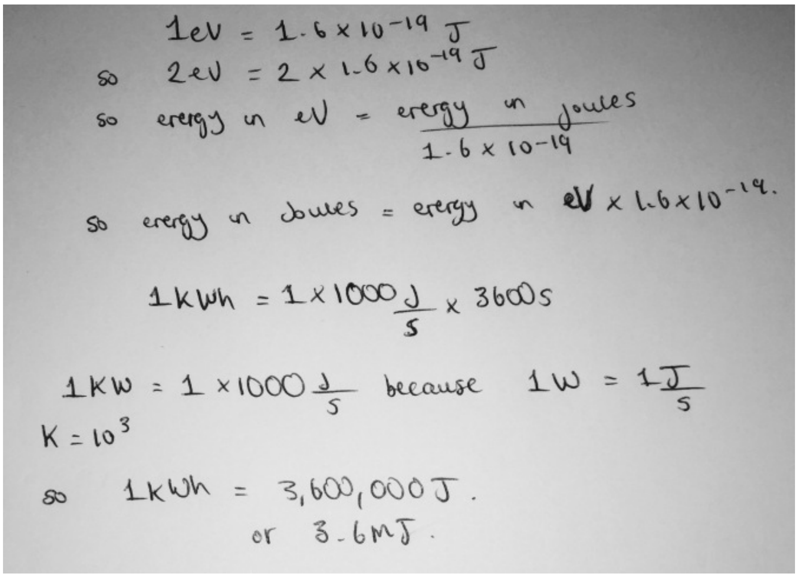
(1) $0.00021 = 0.21\,mm$ because

$0.21 \times 10^{-3} = 0.00021$

(2) $0.00021 = 210\,\mu m$ because

$210 \times 10^{-6} = 0.00021$.

Converting between J and eV, J and kWh.



$1\,eV = 1.6 \times 10^{-19}\,J$

so $2\,eV = 2 \times 1.6 \times 10^{-19}\,J$

so $\text{energy in eV} = \dfrac{\text{energy in joules}}{1.6 \times 10^{-19}}$

so $\text{energy in joules} = \text{energy in eV} \times 1.6 \times 10^{-19}$.

$1\,kWh = 1 \times 1000\,\dfrac{J}{s} \times 3600\,s$

$1\,kW = 1 \times 1000\,\dfrac{J}{s}$ because $1\,W = 1\,\dfrac{J}{s}$

$K = 10^{3}$

so $1\,kWh = 3{,}600{,}000\,J$.

or $3.6\,MJ$.

3.1.2 limitation of physical measurements

Content

- Random and systematic errors.
- Precision, repeatability, reproducibility, resolution and accuracy.
- Uncertainty:
  Absolute, fractional and percentage uncertainties represent uncertainty in the final answer for a quantity.
- Combination of absolute and percentage uncertainties.
- Determine the uncertainties in the gradient and intercept of a straight-line graph.
- Individual points on the graph may or may not have associated error bars.

Opportunities for Skills Development

- Students should be able to identify random and systematic errors and suggest ways to reduce or remove them.
- Students should understand the link between the number of significant figures in the value of a quantity and its associated uncertainty.
- Students should be able to combine uncertainties in cases where the measurements that give rise to the uncertainties are added, subtracted, multiplied, divided, or raised to powers. Combinations involving trigonometric or logarithmic functions will not be required.

Random and systematic errors.

A **random error** is one which is always present in data, and is due to readings that vary randomly, with no recognizable trend or bias. A random error could be caused by a faulty instrument, human error or a poor technique.

A **systematic error** is one which follows a pattern/trend, or a bias, and results in readings that systematically differ from the true mean reading. Systematic errors could be caused by a non-zero reading at the beginning i.e. on a voltmeter/ammeter. There could also be a consistent error in a technique used, or a calibration error in the instrument.

Precision, repeatability, reproducibility, resolution and accuracy.

Precision can be either precision of an instrument, or precision of a measurement. Precision of an instrument is the smallest non-zero value that can be measured, also referred to as the **resolution** of that instrument. The precision of a measurement is the degree of exactness of a measurement, usually referred to as the **uncertainty** of the readings used to obtain a measurement.

Uncertainty

This is the precision of a measurement due to the instrument used.

Absolute, fractional and percentage uncertainties represent uncertainty in the final answer for a quantity.

The **absolute uncertainty** is the size of the range of values that the 'true' value lies. For example in a measurement of 10.0m, the uncertainty is ±0.1m. So the absolute uncertainty would be 10.0m ± 0.1m, as this is the range of values that could be the 'true' value. If you have a range of results ie 0.4, 0.5 and 0.6, the uncertainty is the range of results divided by 2. Also, anomalies must be ignored in these situations.

Fractional uncertainty is simply the calculating by dividing the uncertainty by the value of the data. For example: 1.2 s ± 0.1s, the fractional uncertainty would be equal to 0.1 / 1.2 = $0.08\dot{3}$.

Percentage uncertainty is just the fractional uncertainty multiplied by 100. So for the fractional uncertainty given above, the percentage uncertainty would be $8.\dot{3}$%. So this tells us that the value of 1.2 can deviate by ± $8.\dot{3}$%.

Combination of absolute and percentage uncertainties.

1. If you add or subtract the two (or more) values to get a final value

The absolute uncertainty in the final value is the sum of the absolute uncertainties. For example:

10.0 ± 0.1 mm + 4.0 ± 0.1 mm = 14.0 ± 0.2 mm
10.0 ± 0.1 mm - 4.0 ± 0.1 mm = 6.0 ± 0.2 mm

2. If you multiply one value with absolute uncertainty by a constant the absolute uncertainty is also multiplied by the same constant. For example:

2 x (10.0 ± 0.1 mm) = 20.0 ± 0.2 mm

3. If you multiply or divide two (or more) values, each with an uncertainty you add the % uncertainties in the two values to get the % uncertainty in the final value. For example:

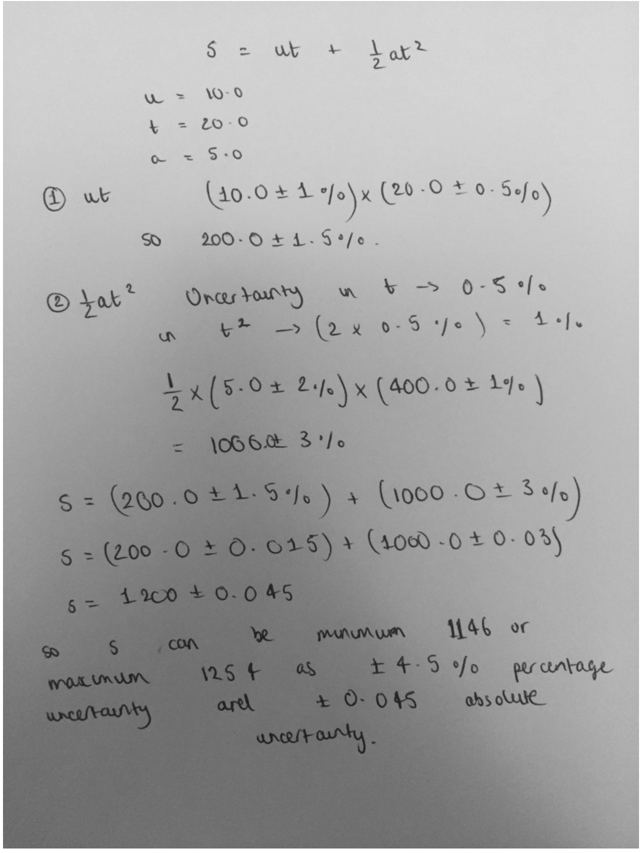
10.0 ± 0.1 mm x 4.0 ± 0.1 mm

This is
10.0 ± 1% x 4.0 ± 2.5%

So the final result is
40.0 ± 3.5%

4. If you square a value, then you multiply the % uncertainty by 2. If you cube a value, then you multiply the % uncertainty by 3. If you need the square root of a value, you divide the % uncertainty by 2.

In the question to the right, you are told to find the absolute and percentage uncertainty in the value of s when using the equation $s = ut + at^2/2$. This is done by combining the uncertainties of ut, and $at^2/2$.


$s = ut + \frac{1}{2}at^2$

$u = 10.0$
$t = 20.0$
$a = 5.0$

① ut $(10.0 \pm 1\%) \times (20.0 \pm 0.5\%)$

so $200.0 \pm 1.5\%$.

② $\frac{1}{2}at^2$ Uncertainty in $t \rightarrow 0.5\%$
in $t^2 \rightarrow (2 \times 0.5\%) = 1\%$

$\frac{1}{2} \times (5.0 \pm 2\%) \times (400.0 \pm 1\%)$

$= 1000.0 \pm 3\%$

$s = (200.0 \pm 1.5\%) + (1000.0 \pm 3\%)$

$s = (200.0 \pm 0.015) + (1000.0 \pm 0.03)$

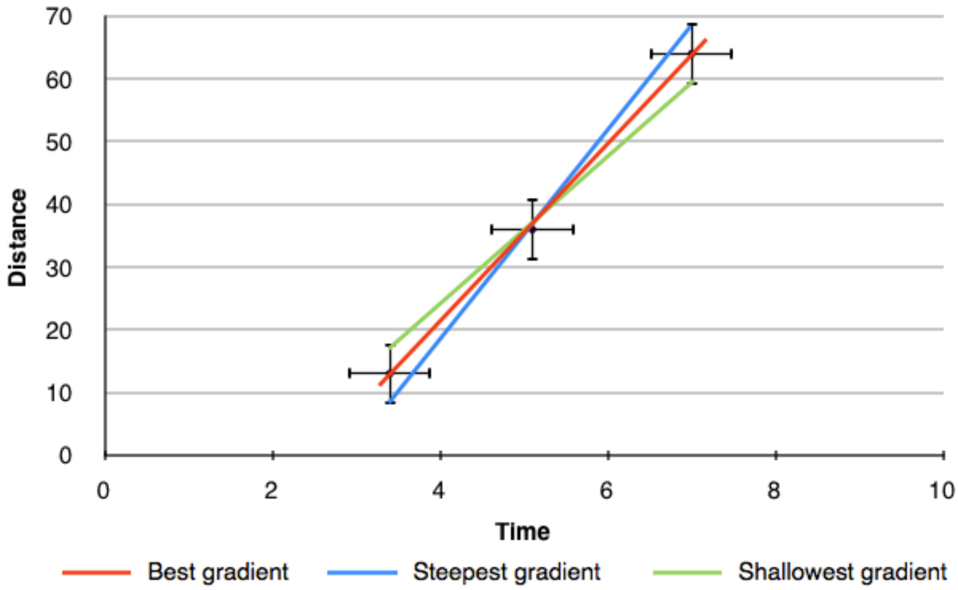
$s = 1200 \pm 0.045$

so s can be minimum 1146 or maximum 1254 as $\pm 4.5\%$ percentage uncertainty and ± 0.045 absolute uncertainty.

1. This question applies knowledge of uncertainties from the last topic.
2. First we need to find the percentage uncertainty on 'ut'. Since 'ut' is two values multiplied together, we have to add their percentage uncertainties. This can be done by finding their fractional uncertainty and then multiplying this by 100. For example, for u: 0.1/10.0 = 0.01 which is the fractional uncertainty. We need the percentage uncertainty, which is 0.1 x 100, so 1%. We know that the percentage uncertainty on u is 1%, and on t is 0.5%, so the final percentage uncertainty on 'ut' is 200.0 ± 1.5%.
3. On $\frac{1}{2}at^2$, we have to find the percentage uncertainty on t, and add it to that of a. ½ does not carry an uncertainty. So we know that the uncertainty on t is 0.5%, so the uncertainty on t^2 is therefore 0.5% x 2, so 1%. Then we need to find the percentage uncertainty on a, which is 2%, and add this to that of t^2. This gives an answer of 1000.0 ± 3%.
4. Now we have the percentage uncertainty on the product of 'ut' and '$at^2/2$'. However these two quantities are added together in the equation $s = ut + at^2/2$, so to add the uncertainties we need to convert to fractional uncertainties.
5. The final answer is therefore 1200 ± 54 as an absolute uncertainty, or 1200 ± 4.5% as a percentage uncertainty. The absolute uncertainty is worked out using either the fractional or percentage uncertainty, as it it just the range of values that the answer could be, using the fractional or percentage uncertainty will give the same answer.

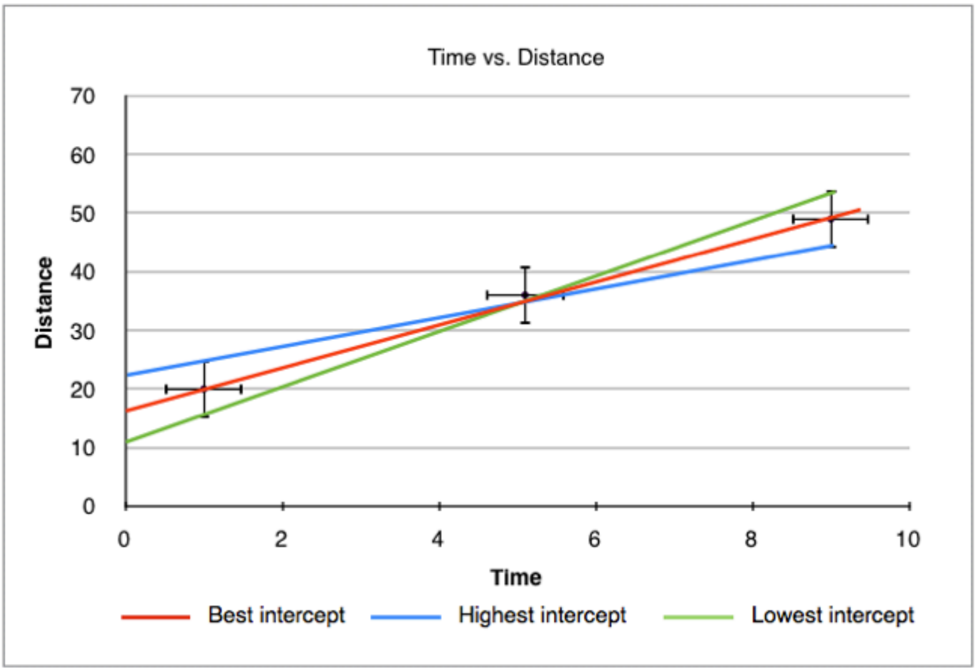
Determine the uncertainties in the gradient and intercept of a straight-line graph

To determine the uncertainty in the gradient of a graph you simply simply add error bars to the first and last point, and then draw a straight line passing through the lowest error bar of the one points, and the highest in the other and vice versa. This gives two lines, one with the steepest possible gradient and one with the shallowest, we then calculate the gradient of each line and compare it to the best value. The figure below shows how this is done.



$$\text{percentage uncertainty} = \frac{|\text{best gradient} - \text{worst gradient}|}{\text{best gradient}} \times 100\%$$

To determine the uncertainty in the y – intercept we do the same thing as when calculating the uncertainty in gradient. This time however, we check the lowest, highest and best value for the intercept by drawing the different possible intercepts from the different gradients.



$$\text{percentage uncertainty} = \frac{|\text{best } y \text{ } intercept - \text{worst } y \text{ } intercept|}{\text{best } y \text{ } intercept} \times 100\%$$

Individual points on the graph may or may not have associated error bars.

3.1.3 Estimation of Physical Quantities

Content

- Orders of magnitude.
- Estimation of approximate values of physical quantities.

Opportunities for Skills Development

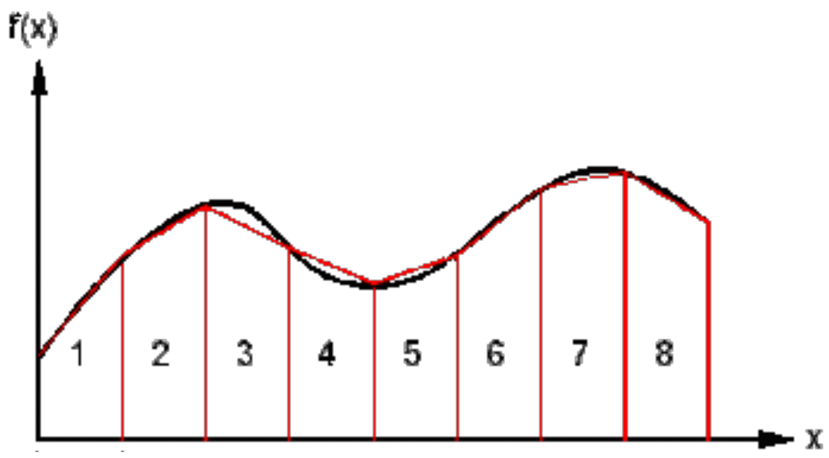
- Students should be able to estimate approximate values of physical quantities to the nearest order of magnitude.
- Students should be able to use these estimates together with their knowledge of physics to produce further derived estimates also to the nearest order of magnitude.

Orders of Magnitude

An order-of-magnitude estimate of a variable whose precise value is unknown is an estimate rounded to the nearest power of ten. For example, there are two orders of magnitude between 10^4 and 10^6, so a factor of 10^2 difference between them.

Estimation of approximate values of physical quantities

When making estimates, it is reasonable to give the figure to one or two significant figures since the estimate is not supposed to be completely precise. For example, the mass of a car to be 1000kg, or the length of a football pitch to be 100m. Or you could be asked to estimate the area under a graph of a curved line. This can be done by drawing trapeziums in, so you can calculate the area of regular trapeziums along the line. This is shown in the diagram below:



Guide to good experimental methods and practice

- Clear method i.e. specific time intervals, values measured etc.
  - Explain the method as if you are explaining it to someone with absolutely no subject and experimental knowledge.
- Equipment required e.g. metre rule, stopwatch etc.
  - How to use the equipment?
    - Are you going to use the metre rule vertically upright to measure something? With a set square to ensure verticality…
- What variables must be controlled e.g. temperature, light intensity etc.
- How can you make results as accurate as possible?
  - Reducing **parallax** error e.g. stand eye level to measuring equipment
  - If liquid is involved, STIR the liquid regularly to ensure even distribution of thermal energy (uniform heating) throughout.
  - Repeat measurements and calculate a mean
    - For example, of diameter of a wire (using micrometer, vernier callipers)
  - Make sure equipment does not have a zero error.
  - Take heat source away when making measurements (if there is one in the question) and depending on context of question.
- Find uncertainty on measurements
- Can you plot a graph from your results?
  - Can you find a relationship between your data that will yield a straight line when plotted on a graph?
    - Find proportionality between variables
    - Compare to $y = mx + c$
    - Take natural logs to both sides

Guide to graphs

- Check units of graph
- If question asks for only the gradient, it will require no units as the gradient is just a measure of how one variable changes with respect to another.
  - If it requires the quantity, make sure to give units
- **Check to see if graph starts at 0 when you are calculating the gradient**

<u>Exam Questions</u>

Edexcel Jan 2010 Unit 3B Question 5di

Question:

State what further measurements the student would need to take to determine the resistivity of the wire. (in previous questions you gained results regarding length and resistance of the wire)

Answer:

Remember it says **measurement**, not a calculable value, so you would need to **MEASURE** diameter.

Exam tip:

WHEN ASKED FOR MEASUREMENTS, DO NOT GIVE QUANTITIES THAT MUST BE CALCULATED!

Edexcel Jan 2011 Unit 6 Q4bi)c)

Question:

Explain why a graph of $\ln\Delta\theta_0$ against t should be a straight line.

Answer:

We were told $\Delta\theta = \Delta\theta_0 e^{-kt}$ in a previous question, so $\ln\Delta\theta = -kt + \ln\Delta\theta_0$. If we compare this with the equation of a line $y = mx + c$, you can see that the gradient is equal to '-k'. Since k is a constant, your gradient will be a constant, yielding a straight line.

Exam tip:

WHEN ASKED ABOUT RELATIONSHIPS BETWEEN VARIABLES AND THEIR REPRESENTATION ON A GRAPH, THINK ABOUT PROPORTIONALITY OR COMPARISON TO $y = mx + c$ IN ORDER TO FIND OUT WHETHER IT COULD BE A STRAIGHT LINE.

Question:

Your teacher suggests using a temperature sensor and a data logger in place of the thermometer and stop clock.

State an advantage of using a temperature sensor and a data logger in this experiment.

Answer:

Takes simultaneous readings/plots graph automatically

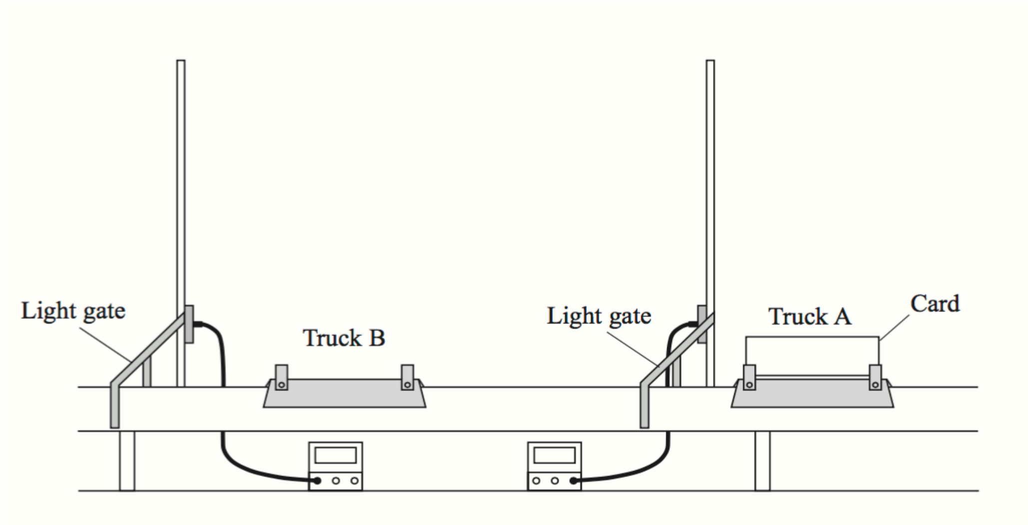
Exam tip:

ADVANTAGES EXPERIMENTALLY – EASE OF DATA COLLECTION

Edexcel Jan 2011 Unit 6 Q2a

Question:

A student has an air track which has two trucks, A and B, supported by a cushion of air. He does an experiment to see whether momentum is conserved when the two trucks collide.



Using an air track reduces friction on the trucks. State why this is important in a momentum conservation experiment.

Answer:

Conservation of momentum only applies in there are no (resultant) external forces

Question:

The student uses two light gates as shown in the diagram. Truck A carries a card of negligible mass and length *l*. A light gate records the time *t* taken by the card to pass through it.

Explain how you would show that the air track is horizontal before starting the experiment.

Answer:

Truck A given a (gentle) push (1)
The times shown on both timers are similar/calculated velocities are similar (1)
<u>OR</u>
Put truck on track, check if it remains stationary (1) Check in more than one position/use both trucks (1)
<u>OR</u>
Use spirit level (1) Check bubble in middle/check in more than one position (1)
<u>OR</u>

Check height of track above bench with rule and set square (1)
At both ends (1)

Question:

Truck B carries no card and is placed so that it is stationary between the light gates. Truck A is set off towards truck B. As the card passes through the first gate it records a time t_1. Truck A then collides with truck B. They stick together and move through the second gate which records the time t_2

Both trucks have the same mass. Explain why $t_2 = 2t_1$ if momentum is conserved.

Answer:

Mass doubles
(So) velocity halves

time = (card) length/velocity

(so time is doubled)

allow mathematical proof which hides v ratio e.g. $mu = 2mv$ then we know that $u = l/t_1$, and $v = l/t_2$ so substitute these values in and solve for $t_2 = 2t_1$

Question:

The student records the following data for 5 separate collisions:

t_1/s	0.34	0.15	0.21	0.28	0.24
t_2/s	0.70	0.35	0.39	0.55	0.52
t_2/ t_1	2.1	2.3	1.9	2.0	2.2

Use this data to discuss whether momentum can be considered to be conserved in this experiment.

Answer:
(We know that since $t_2 = 2t_1$ for conservation of momentum, $t_2/t_1 = 2$)

1. Mean ratio $t_2/t_1 = 2.1$ (1)
2. Uncertainty is + 0.2 (1)
3. Uncertainty range includes 2.0 (1)
4. (Hence, yes, momentum is conserved)

<u>Alternatives for last 2 marks</u>

1. Calculates % difference as 5% (1)
2. 5% is less than the experimental uncertainty of 9.5% (1)
3. (Hence, yes, momentum is conserved)

Edexcel AS Specimen 1 Q11b

Question:

The length of a tooth from another dinosaur is approximately 10cm.

Scientist A measures this length with a metre rule, and scientist B measures this length with calipers.

Scientist B claims that his measurement will produce a more accurate value for the length of the tooth.

Comment on the claim made by scientist B.

Answer:

- Accuracy relates to how close the measurement is to the true value
- Callipers reduce random/measurement errors in determining the value, giving a lower uncertainty in the measurement than that for a metre rule
- so scientist B has not made a more accurate measurement he has made a measurement with lower uncertainty

Edexcel AS Specimen 2 13b

Question:

The refractive index of glass may be determined by measuring angles of incidence and angles of refraction for light passing into a glass block.

Explain how the choice of the width of the ray of light and the range of the angles of incidence can ensure the accuracy of the result

Answer:

- A narrow ray should be used
- Because it reduces uncertainty in the position (angle) of the ray (accept allows position to be determined with greater precision)
- A range of large angles should be used
- Because the precision of the measurement will be determined by the protractor
- For larger angles the percentage uncertainty will be smaller
- A smaller uncertainty in the final answer from sin i/sin r

Exam tip:

WHEN ASKED ABOUT ACCURACY, TALK ABOUT HOW UNCERTAINTY (PRECISION OF MEASURING INSTRUMENTS FOR INSTANCE), WILL AFFECT THE ACCURACY OF THE RESULT.

ACCURACY RELATES TO HOW CLOSE THE MEASUREMENT IS TO THE TRUE VALUE

Edexcel AS Specimen 2 Q17a)d)

Question:

The student wants to determine the mass of one of the rubber bands. He places five rubber bands on a balance and obtains a reading of 2 g. He divides the reading on the balance by five to determine the mass of one rubber band.

Explain how he could improve his result.

Answer:

- Balance measures to 1 g
- More rubber bands should have been placed on the balance to obtain a reading of at least 10g
- To make the reading more precise thus reduce uncertainty on the measurement

Question:

The student thinks the calculated value of maximum velocity is too high because the band does not travel as far as expected.

Explain how the student could determine the initial velocity with the use of a video camera and why light gates would not be suitable

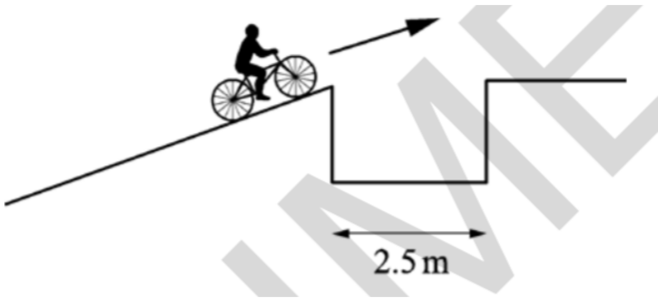
Answer:

- Video the band over a short distance so it determines the initial speed
- **Or** because its speed will rapidly reduce because of air resistance **(1)**
- Include a scale or object of known length in the area filmed **(1)** analyse the video to determine the time taken to travel the known distance **and** calculate the speed using the measured time in speed = distance/time **(1)**
- (Light gates would not be suitable because) the band is not sufficient in size to interrupt the light gate beam

OCR (A) A Level Specimen 1 Q17c

Question:

The cyclist continues to move up the slope at 6.0 ms^{-1} and approaches a gap of width 2.5 m as shown in **Fig. 17.2**.



A student has calculated that the cyclist will be able to clear the gap and land on the other side. Another student suggests that this calculation has assumed there is **no** drag and has not accounted for the effect caused by the front wheel losing contact with the slope before the rear wheel.

Without calculation, discuss how drag and the front wheel losing contact with the slope will affect the motion and explain how these might affect the size of the gap that can be crossed successfully.

Answer:

- Drag reduces velocity **or** increases time to cross **or** some kinetic energy of cyclist goes to heat. Very short crossing time
- Longer crossing time results in cyclist at lower point on other side of gap
- Moment on bicycle
- Rotation lowers height of front wheel

OCR (A) A Level Specimen 1 Q18a

Question:

A group of scientists have designed an alloy which is less dense than copper but may have similar mechanical properties. A researcher is given the task to determine the Young modulus of this alloy in the form of a wire.

Write a plan of how the researcher could do this in a laboratory to obtain accurate results. Include the equipment used and any safety precautions necessary.

Answer:

Equipment used safety

- Wire fixed at one end with load added to wire
- Suitable scale with suitable marker on wire.
- Micrometer screw-gauge or digital/vernier callipers for measuring diameter of wire
- Reference to safety concerning wire snapping

Measurements

- Original length from fixed end to marker on wire
- Diameter of wire.
- Measure load.
- New length of wire when load increased.

Calculation of Young modulus

- Find extension (for each load) OR strain
- Determine cross-sectional area of wire or stress
- Plot stress-strain graph OR graph of load-extension
- Young modulus = gradient OR Young modulus equals gradient x original length/area
- Calculate Young modulus from single set of measurements of load, extension, area and length

Reliability of results

- Measure diameter in 3 or more places and take average.
- Put on initial load to tension wire and take up ‘slack’ before measuring original length.
- Take measurement of extension while unloading to check elastic limit has not been exceeded
- Use long wire (to give measureable extension and reduce percentage uncertainty)
- Scale or ruler parallel to wire. Readings read off parallel to scale (reduce parallax error)

Edexcel (IAL) Unit 6 June 2014 Q4b

Question:

Plan an experiment to determine how the resistance of a thermistor changes as its temperature is increased from 0 °C to 100 °C.

Your plan should include:

(i) the apparatus required, **(2)**

(ii) how you would obtain the temperature range, **(1)**

(iii) the precautions you would take to ensure accurate measurements. **(2)**

You may draw a diagram if you wish.

Answer:

Apparatus - **Max 2** Thermometer Ohmmeter **or** ammeter and voltmeter (Must have circuit diagram for V & A with psu) heat source (can be awarded in diagram or list)	 (1) (1) (1)
Method use ice(to get to 0 °C) **and** heat(to get to 100 °C)	 (1)
Precaution - **Max 2** Anything appropriate such as removing heat source when reading stirring Keep thermometer close to thermistor **Or** Keep thermometer away from sides/bottom Do not allow repeat readings	 (1) (1) (1)

Edexcel Unit 6 Jan 2011 Q3aii

Question:

V/V	W/mJ			Mean W/mJ	C/mF
4.5	19.57	19.51	19.63		
6.0	36.14	36.12	36.22		

Calculate the percentage difference between your two values of C

(They were calculated to be 1.93 and 2.01 for 4.5V and 6V respectively)

Answer:

Percentage difference between values calculated
using mean C as denominator

e.g. (2.01 – 1.93)/1.97 = 4(.1)%

Question:

The uncertainty in the values of potential difference in the table is 0.1 V.

Estimate the uncertainty in your mean value of W when using the 4.5 V battery.

Answer:

Use half range to estimate uncertainty (1) [must include unit]
Uncertainty is 0.06 mJ

Question:

Use these uncertainties to estimate the percentage uncertainty in the value of C obtained using the 4.5 V battery.

Answer:

- Calculates percentage uncertainties in V and W
- Combines percentages appropriately

W = 0.3% & V = 2.2%
C = [0.3+(2×2.2)]%=4.7%

(Remember if you square a value its percentage uncertainty is multiplied by 2).

Question:

Explain whether the unknown capacitor could be a 2200μF capacitor with a tolerance of 20%

Answer:

- Calculates lower limit of range of 2200μF as 1760μF
- States that that (mean *C* – uncertainty on C) lies within range

Edexcel June 2010 Unit 6 Q4a

Question:

You are to plan an experiment to investigate the ability of gamma rays to penetrate lead. You are then to analyse a set of data from such an experiment.

You have a source of radiation and a detector and counter. Describe briefly a simple experiment to confirm that the source emits gamma radiation.

Answer:

- Record background count (rate)
- Place thick aluminium/thin lead between source & detector **OR** Distance greater than 25 cm between source and detector
- Count rate detected above background

Question:

You are provided with sheets of lead and apparatus to support them safely between the source and the detector.

The thickness of lead affects the count rate. Describe the measurements you would make to investigate this.

Your description should include:

- A variable you will control to make it a fair investigation
- How you will make your results as accurate as possible
- One safety precaution

Answer:

Keep distance between the source and detector constant

Any **four** from:

- Record count (rate) for different thicknesses
- Record count for a specified time
- Subtract background count
- Take several readings at each thickness
- Measure thickness with micrometer screw gauge/Vernier calipers

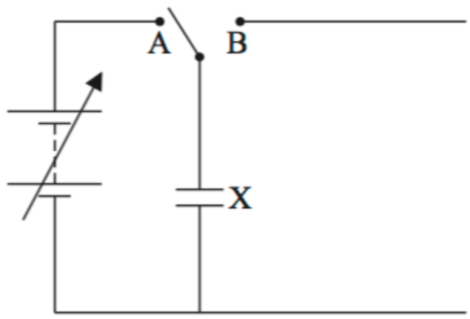
One of:

- Keep people away from source
- Use tongs to handle source
- Use tongs to handle lead sheets
- Ensure source held securely
- Limit exposure time to source

Edexcel (IAL) Unit 6 June 2016

Question:

Part of an electric circuit is shown.



When the switch is connected to terminal A the capacitor X is connected to the variable power supply.

(a) (i) Add a second capacitor Y to the circuit so that it is connected in parallel with X when the switch is moved to B.

(1)

(ii) Add a voltmeter so that the potential difference (p.d.) across X can be measured when the switch is in either position.

(1)

(b) The capacitance of X is C_X. If C_X is known, this circuit can be used to determine the capacitance C_Y of capacitor Y using the equation

$$V_2 = \frac{C_X}{C_Y}(V_1 - V_2)$$

where

- V_1 is the p.d. across X when it is connected to the power supply
- V_2 is the p.d. across X when Y is connected in parallel with it.

Write a plan for an experiment using this circuit and a graphical method to determine C_Y.

Your plan should include

(i) the readings you would take

(2)

(ii) the graph you would plot and how you would use the graph to determine C_Y

(2)

(iii) how you would ensure the capacitors would not be damaged during the experiment

(1)

(iv) a precaution you would take to ensure the results are accurate.

(1)

Answer:

2(a)(i)	Y connected correctly	**(1)**
2(a)(ii)	Voltmeter connected correctly	**(1)**
2(b)(i)	**2b to be marked holistically** Record V_1 and V_2 For various values of the supply/V_1	 **(1)** **(1)**
2(b)(ii)	Plot a graph of V_2 (on the y-axis) against ($V_1 - V_2$) (on the x-axis) $C_Y = C_X$ / gradient	**(1)** **(1)**
2(b)(iii)	Supply p.d. does not exceed working p.d. for either capacitor/C **Or** Capacitors are connected with polarity correct (if electrolytic)	 **(1)**
2(b)(iv)	Ensure that capacitor Y is discharged before each reading (accept both capacitors are discharged) **Or** check for zero error on voltmeter	 **(1)**

Edexcel (IAL) Unit 6 Jan 2016 Q1bi

Question:

The volume V_2 of the bung is given by

$$V_2 = \frac{\pi h}{12}\left(D^2 + d^2 + Dd\right)$$

where D, d and h are the dimensions shown on the diagram.
The student uses callipers to take measurements of the bung.

(i) Describe how h should be measured.

Answer:

- Holds top and bottom of bung between jaws (perpendicularly) **or** callipers are parallel to h (1)
- Repeat at different orientations for mean
  Or do not compress
  Or check for zero error8

Key exam tips:

- **REMEMBER TO CONVERT TO KELVIN FROM CELCIUS WHEN DEALING WITH NUCLEAR PHYSICS QUESTIONS!**
  - **pV = nRT = NkT - The 'T' is in KELVIN not Celsius.**
- **CASSEGRAIN TELESCOPE - ENSURE RAYS DO NOT CROSS BEFORE THEY LEAVE THE SECONDARY MIRROR! (SO, AS THEY LEAVE.)**
- **GIVE SPECIFIC DETAILS IE CALCULATIONS OR FIGURES TO PRESENT YOUR CONCLUSION! FOR EXAMPLE:**

AQA June 2015 Unit 5 Q1c

Question:

Discuss the level of detail the IRTF would be able to detect on the surface of Vesta, when Vesta is 1.73 x 10^{11}m from Earth. (We already know that the angular resolution of the IRTF is The smallest angle the telescope can resolve is 3.3 × 10^{-7} radian, and that Vesta subtends an angle of approximately 3 x 10^{-6} radian from Earth.)

Answer:

- Minimum angular resolution is better/smaller than the size of the asteroid.
- Details of about 1/10 the angular size of Vesta/ 50km can be seen

- **GIVE SPECIFIC DETAILS – FOR EXAMPLE:**

Question:

The black body temperature of each star is approximately 9200 K.
Explain why a Hydrogen Balmer line was chosen for the analysis of wavelength variation

Answer:

- The temperature (9200K) indicates that the star is in spectral class A.
- Hydrogen Balmer lines are strongest in A class stars and therefore would be more easily measured

  - **BE EXPLICIT IN WHAT YOU SAY! DIRECTLY STATE THAT 9200K IS RELATED TO SPECTRAL CLASS A!**
- **WHEN DEALING WITH m-M = 5LOG(d/10) REMEMBER TO CONVERT DISTANCE INTO PARSECS!**
- **ALSO, REMEMBER A LOWER VALUE ON THE APPARENT MAGNITUDE SCALE = BRIGHTER TO THE NAKED EYE AS SEEN FROM EARTH!**
  - **THIS MEANS THAT AN APPARENT MAGNITUDE OF 1 IS BRIGHTER THAN AN APPARENT MAGNITUDE OF 2.**

- **WHEN USING $P = \sigma A T^4$ REMEMBER THAT 'A' WILL BE $4\pi R^2$ (IF IT IS A SPHERE, FOR EXAMPLE AN IDEALISED STAR)**

And finally, some good old-fashioned notes…

Oscillations

- Perform 3 sets of measurements for each different oscillation, (you will get more marks if you do 2 sets of repeats).
- Measure at least 30 periods in total.
- Preferably make each measurement 20 periods long.
- Precaution: minimise oscillations in any other plane other than the one being observed ("Careful release to avoid unwanted modes of oscillation"). Explain how you did this.
- Always write times to two d.p., never to the nearest second.
- Precaution: do small amplitude oscillations
- Precaution: say that you did several periods at once to minimise reaction time errors.
- Precaution: use a fiducial marker at the centre of the oscillation.

Moments

- Precaution: balance the ruler being used first.
- Use distances from the pivot of greater than 25 cm (250 mm).
- Weigh the unknown and known masses in your hands before using the ruler, and place the lighter mass as far from the pivot as possible.
- Measure distances from the pivot to the centre of mass of the object.
- All measurements should be to 1 mm accuracy.
- To make sure the rule is balanced, pull each end down. If it comes up again then the rule must have equal moments acting on it on either end.

Density Measurements

- When using a micrometer, one full rotation of the barrel is 0.5 mm (50 on the barrel scale).
- The micrometer reads to 0.01 mm accuracy.
- Vernier callipers can read to 0.05 mm accuracy. However, it is advisable to quote the figure to 0.1 mm accuracy, as this will give a larger uncertainty, which will make comparisons in later parts of the question easier.
- If measuring a very small dimension, measure several "thicknesses" of it. Remember to divide by the number of thicknesses after the measurement!
- Precaution: check the zero error on the micrometer and/or Vernier callipers. Wipe the jaws of the micrometer to remove grease.
- Give answers to 2 or 3 s.f. it is meaningless to write, for example, "density is 7785.654 kg m^{-3}"!
- Always take at least 3 readings for each measurement and take an average.
- When measuring string diameters or foil thicknesses (or similar), use a minimum of 10 thicknesses.

Miscellaneous

- With a measurement that varies substantially each time you test it, take at least 4 readings. An example is sand falling from a funnel.
- For Experiment C, 8 readings are normally sufficient (sometimes even 6). Extra time at the end can be used for writing up the other experiments or planning them.
- Show clearly on diagrams your measurements, e.g. to the centres of mass of objects when doing a moments experiment.
- In any experiment that involves loading and unloading, state that you checked the original height on unloading each time.
- In any experiment involving, e.g. a funnel and sand, state that you kept the funnel vertical.

- Precaution: with many experiments, you can state that you did something to avoid parallax error.
- When measuring angles, measure from the underside of, e.g., the board you are measuring the angle of, compared to the horizontal bench.
- To measure a height with a ruler and a set square, hold the ruler vertically using the set square against the bench and the flat side of the ruler.
- Show any angles measured on diagrams, including ones of forces.

Uncertainties

- % Uncertainty = $\frac{error}{measurement} \times 100$
- When multiplying or dividing quantities, add their % uncertainties together.
- When adding or subtracting quantities, add their absolute errors together, then divide by the result of the addition/subtraction of the measurement, e.g. for $(d + x)$, where $x = 10mm \pm 0.1mm$, and $d = 5mm \pm 0.02mm$, the absolute errors added = 0.102 mm. Therefore the % uncertainty is:
- $= \frac{0.102}{(10+5)} \times 100$
- If you have to calculate the error in, e.g. $x - \pi d$, the absolute error in *d* must be multiplied by pi and then added to the absolute error in *x*. The percentage uncertainty is this total error divided by the calculated $x - \pi d$ and the result multiplied by 100.
- If a measurement is to be raised to a power, then multiply the % uncertainty in the measurement by the power to get the % uncertainty in the overall term.
- If two values, for say, a density are available, calculate the % difference between them. If a value is given by the examiner, then use this as the "correct" value, and calculate the % difference the following way: $\frac{x - c}{c} \times 100$ where *x* is your measured value, and *c* is the examiner's value. If you have obtained two values, then the expression changes: $\frac{x_1 - x_2}{\bar{x}} \times 100$ where x_1 and x_2 are your measured values, and $\bar{x}$ is the median of the two, (not necessarily the mean!).
- Compare the % difference with your % uncertainty. Any relationship suggested, such as that the two densities should be equal, can be considered correct if your % difference is less than your % uncertainty. This will gain you marks!
- If your % uncertainties look small, check that you have multiplied by 100!

Electrical Experiments

- With capacitor discharges, either take readings every 5 seconds for the first part of the discharge, or I think that every 10 seconds is sufficient.
- If a range is specified over which you should take measurements, do not exceed it: you will be penalised.
- With an analogue ammeter, use the top scale. This reads (generally), from 20, to 0, to 10. These are in fact divisions of 10 m A, and the meter actually reads from -20 to 100 m

A. If you are out by a factor of 10, (e.g. you get a calculated cell voltage of 0.15 V), check that you have read the meter correctly. Always remember that the polarity on the meter must be correct.

- Any small discrepancy in your results can be explained by "electrical resistance at the contacts in the circuit".
- With most electrical experiment where a curve will be obtained (e.g. the V/I characteristic of a diode), 9 points on a smooth curve are sufficient.

Graphs

- With any graph, a minimum of 6 to 8 points are needed, and you must have at least 4 points on a curve.
- When measuring the gradient of a graph, carry your tangent on to the sides of the graph paper, however big your graph. The triangle you use should be greater than 10 cm in length and height, although in some mark schemes 100 cm^2 is fine.
- Your graph does not have to go through the origin. If the data does not indicate that it does so, do not force it to. Comment on the fact that there must have been a systematic error.
- When choosing values to read of a graph, it is better to take them from the middle part of the curve, as this is where you will have more points per change in y co-ordinate.
- When describing your "plan" in Experiment C, state that the graph you plot will be a straight line through the origin (if this is the case!), of gradient = to an expression which will help you confirm the relationship suggested by the examiner.
- Turning points on graphs require at least 4 points.
- If points near the origin deviate substantially from your line of best fit, point out that for small measurements there is a greater uncertainty.

Experiments Involving Temperature

- Readings should be accurate to fractions of a degree.
- Stir any liquid being heated.
- Insulate the apparatus if possible.
- The thermometer should not be touching the sides of the container it is in, and should be in the middle of the liquid you are measuring the temperature of.
- Precaution: read the thermometer at eye level to avoid parallax error.
- The bulb of the thermometer should be completely submerged.

Comment on the result obtained being the right order of magnitude

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