GCSE to A-level progression: Student transition activities answer booklet – Physics

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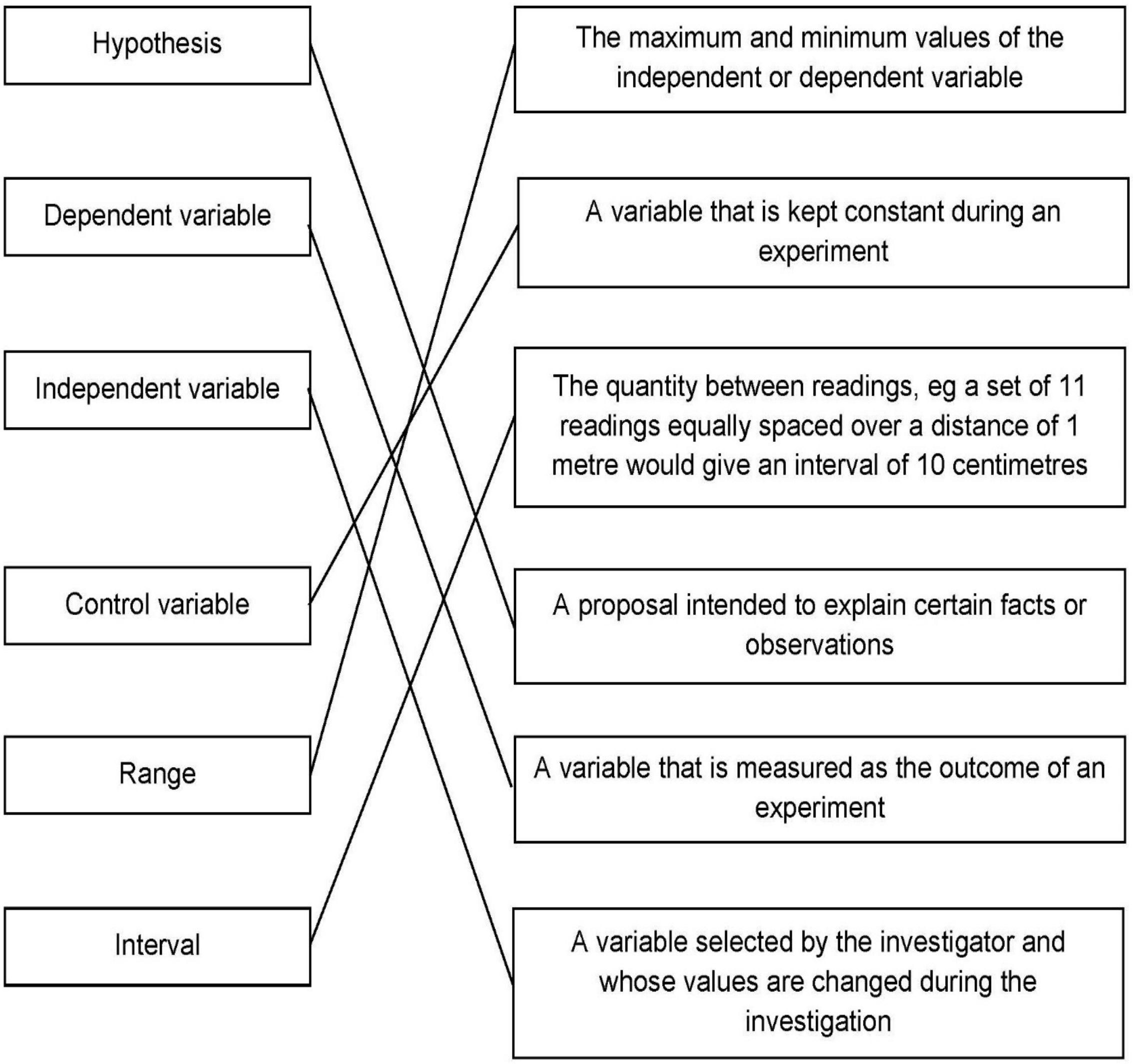
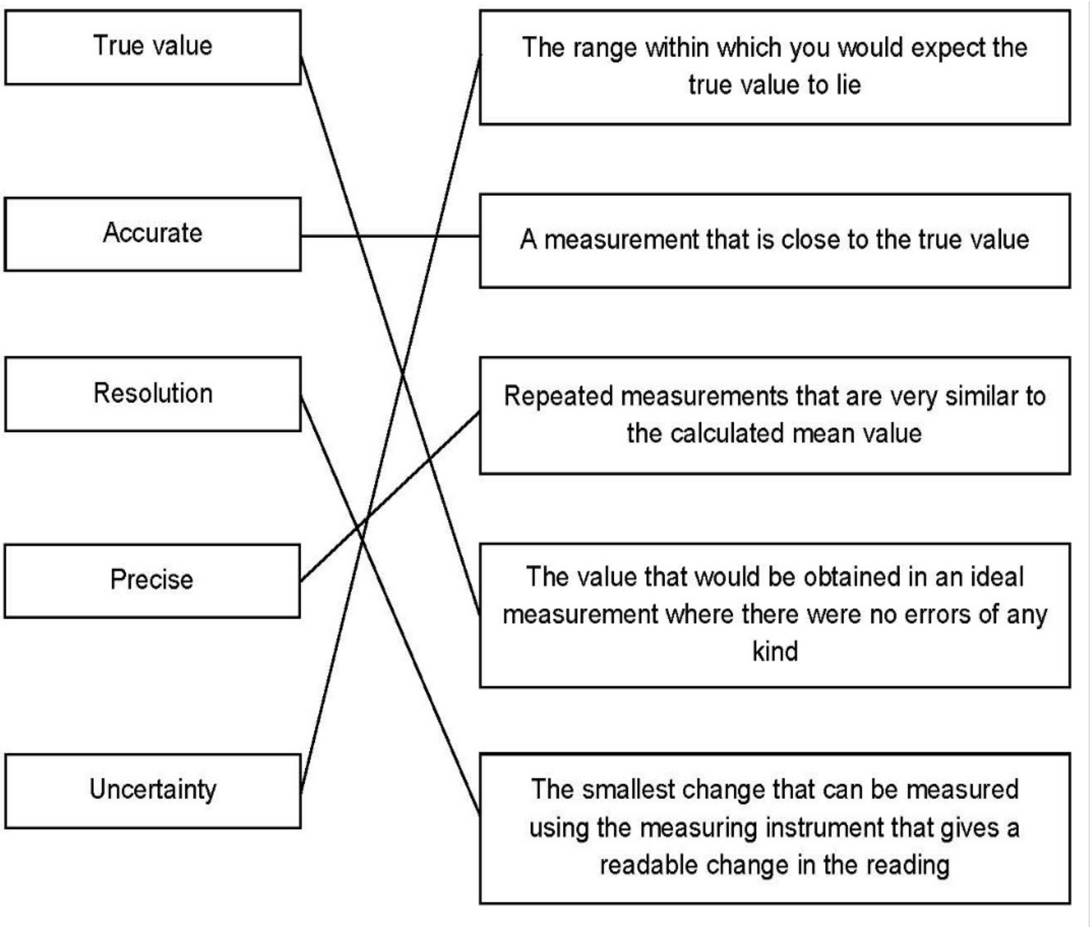
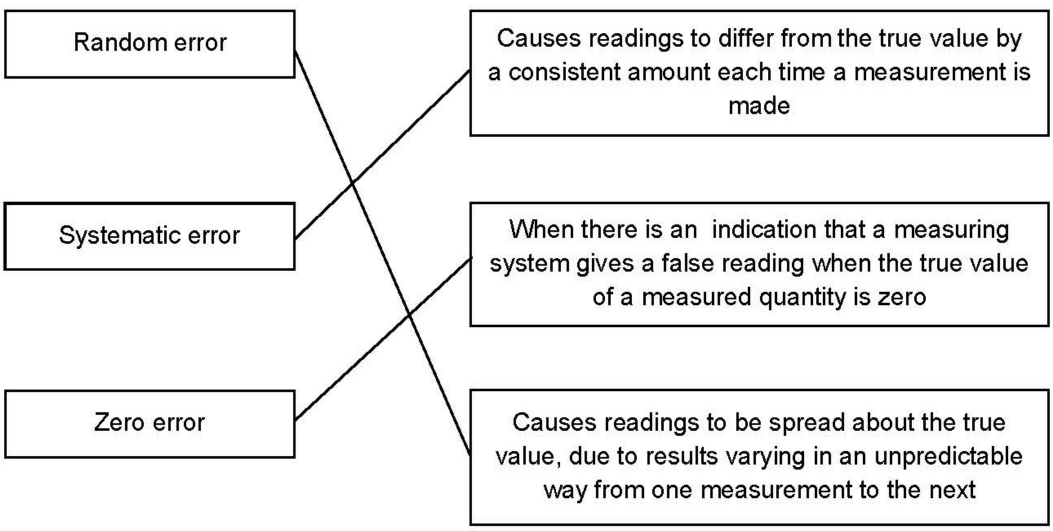
Activity 1 Scientific vocabulary: Designing an investigation



Activity 2 Scientific vocabulary: Making measurements



Activity 3 Scientific vocabulary: Errors



Activity 4 SI units and prefixes
1. a. 60 s b. 0.001A c. 1000 kg
2. a. cm or mm b. K c. s or ks d. nm or pm e. kg f. A

Activity 5 Converting data
1. 1500 m
2. 0.000 450 kg
3. 96 700 000 Hz (typical local radio station frequency)
4. 0.000 000 005 metres (iPhone 12 chip specification)
5. 3 900 000 000 watts (output from Drax power station)

Activity 6 Investigating springs
1. The extension of the spring will be proportional to the force applied.
2. **Independent variable**: force applied **Dependent variable:** extension **Control variable:** stiffness of spring
3. **Reproducible**: A measurement is reproducible if the investigation is repeated by another person, or by using different equipment or techniques and the same result is found. **Repeatable**: A measurement is repeatable if the original experimenter repeats the investigation using the same method and equipment and obtains the same results.
4. 1 mm
5. The student could make sure they were at eye level with the end of the spring when taking the readings. This would ensure they not viewing the ruler from above or below.
6. Repeated the experiment, ignored any anomalous results, and found the mean.

7.	Systematic error
8.	Mean: 3.1, 5.9, 9.2, 12.0, 15.1
9.	The spring stiffness constant.

8.

Mean
3.1
5.9
9.2
12.0
15.1

Activity 7 Using Greek letters

Object or quantity represented by the Greek letter	Greek letter
Wavelength	λ
Type of ionising radiation which cannot pass through paper and is used in smoke detectors.	**α**
Unit of electrical resistance	Ω
Type of ionising radiation which is an electron ejected from the nucleus. Can be used to monitor paper thickness.	**β**
Very short wavelength electromagnetic wave.	**γ**

Activity 8 Using the Physics formula and data sheet

1.
   a. Photon: γ
   b. Neutrino: ν
   c. Muon: μ
   d. Meson: π or K

2. The Greek letter rho (ρ) is used to represent density and resistivity.

Activity 9 Using the delta symbol

1. Speed and distance are **scalar** quantities, with size **only**.

   Velocity and displacement are **vector** quantities, with both size **and** direction.

2. There are two in the A-level formula sheet that look similar to the formulas you would have seen at GCSE:

A-level formula	GCSE formula
Gravitational potential energy $\Delta E_p = m\,g\,\Delta h$	Gravitational potential energy $E_p = m\,g\,h$
Hooke's law $\mathrm{F} = k\,\Delta L$	Force applied to a spring $F = k\,e$

3. To find the mass of water you will need to use the formula

$$Q = m\,c\,\Delta\theta$$

Which you will rearrange to find *m*:

$$m = \frac{Q}{c\,\Delta\theta}$$

You are given the value for *c* (4200) and can calculate Δθ from the data given (90 – 20 = 70).

But there are two quantities in this formula that you do not know: *m* (which you are calculating) and *Q*. So you need to use another equation to find *Q*:

$$P = \frac{\Delta W}{\Delta t}$$

Which you will rearrange to find ΔW. So the work done by the coffee machine in 20 s is

$$\Delta W = P\,\Delta t$$

$$= 2.5 \times 10^3 \times 20$$

$$= 5.06 \times 10^4$$

(Remember that you need to convert the value for power, which was given in kilowatts, to watts.)

Now you can substitute into the formula to calculate m:

$$m = \frac{5.06 \times 10^4}{(4200 \times 70)}$$

$$= 0.17 \text{ kg}$$

4. Change in length of the pencil Δl = 86.0 – 84.5 = 1.5 mm

   Total length of drawn line = 20 × 25 cm = 500 cm

   To half the original length we need to reduce the length by 86/2 = 43 mm

   For every 500 cm drawn, the pencil length reduces by 1.5 mm: calculate how many times 1.5 mm goes into 43 mm:

$$\frac{43}{1.5} = 28.67$$

   Total length of line needed is 28.67 × 500 = 14335 cm

   = 143.35 m

Activity 10 Rearranging formulas
1. $f = \frac{c}{\lambda}$ (divide both sides by λ)
2. $m = \rho V$ (multiply both sides by V)
3. $s = \frac{\lambda D}{w}$ (multiply both sides by s, then divide by w to leave s)
4. $I = \sqrt{\frac{P}{R}}$ (divide by R then find square root)
5. $v = \sqrt{\frac{2E}{m}}$ (multiply by 2, divide by m then find square root)
6. $\varphi = hf - E_k$ (subtract E_k from both sides)
7. $a = \frac{(v - u)}{t}$ (subtract u^2 from both sides then divide by 2 s)
8. $a = \frac{2(s - ut)}{t^2}$ (subtract ut, multiply by 2 then divide by t^2)
9. $r = \frac{\varepsilon - IR}{I}$ (multiply out brackets to get $\varepsilon = IR + r$, then subtract IR and divide by I)
10. $T = \mu(2lf)^2$ (multiply by $2l$, square both sides then multiply by T)

Activity 11 Standard form
1. a. 3.794×10^{2} b. 7.12×10^{-2}
2. a. 300 000 000 ms^{-1} b. 0.000 000 000 000 000 000 16 C
3. 2.5×10^{5}
4. Correct ascending order: proton rest mass permeability of free space acceleration due to gravity the Avogadro constant mass of the Sun.

Activity 12 Significant figures and rounding
1. 5 rockets
2. 36% (The figures in the question are to 2 significant figures, so the answer should also be to 2 significant figures.)
3. 300 beta particles

Activity 13 Fractions, ratios and percentages
1. 1/20
2. 50 diodes
3. The second pile (250 : 300)
4. 5.44 cm^2
5. 20 cubes
6. 10 faulty components altogether (9 resistors and 1 capacitor)
7. 127 400 metres or 127.4 km
8. Power Station B was offline for longer. Power station A = online 7050 days, offline 450 days. Power station B = online 8640 days, offline 1080 days

Activity 14 Pythagoras' theorem
1. 5.4 cm ($x^2 = 5^2 + 2^2$)
2. 6.0 cm ($10^2 = x^2 + 8^2$)

Activity 15 Using sine, cosine and tangent
3. 2.5 cm
4. 5.0 cm

Activity 16 Arithmetic means

1. 89 kg

   If the mean increases by 1kg when the 10th person is added then the total mass of 10 people would be 10 × 80 = 800 kg.

   9 people have a mean mass of 79kg so their total mass would be 9 × 79 = 711 kg.

   Therefore the 10th person must have a mass of 800 – 711 = 89 kg.

2. $$\frac{150}{12} = 13 \text{ seconds}$$

Activity 17 Gradients and areas

1. Negative acceleration of the car is represented by b (the gradient of the sloping line).

   The distance travelled by the car is represented by a (the area under the graph).

2. You are told that the gradient of the graph is the power output, so you need to calculate the gradient of the graph.

   Any values selected from the graph are acceptable, but it is better to use as large a range as possible. Make sure you choose a point that goes through the gridlines too. For example:

   Gradient = $y_2 - y_1 / x_2 - x_1$
   Gradient = 44 000 – 0 / 20 – 0
   Gradient = 2200
   Power = 2200 W

3. Applying the formula for the area of a trapezoid:

   $$\text{Area} = \frac{a + b}{2} h$$

   From the graph, a = 20, b = 50 and h represents the unknown value v, so:

   $$625 = \frac{20 + 50}{2} v$$

Rearranging to find v:

$$v = \frac{625 \times 2}{70}$$

$$= 17.9 \text{ ms}^{-1}$$

Alternatively you could calculate the area using the left triangle, the middle square and the right triangle, ie

$$\text{Area} = \frac{20\text{ v}}{2} + 20\text{v} + \frac{10\text{v}}{2}$$

$$625 = 10\text{v} + 20\text{v} + 5\text{v}$$

Rearranging to find v:

$$v = \frac{625}{35}$$

$$= 17.9 \text{ ms}^{-1}$$

4. Here you need to calculate the area of the trapezoid, which will give you the distance:

$$\text{Area} = \frac{20 + 50}{2} \times 50$$

$$= 1750 \text{ m}$$

Again, alternatively you could calculate the area using the left triangle, the middle square and the right triangle.

Activity 18 Using and interpreting data in tables and graphs
1. Find where the graph is the steepest and calculate the gradient at that point. For example: $$\text{Gradient} = \frac{170 - 80}{10 - 6}$$ The gradient represents the speed. So speed = 22.5 ms^{-1}
2. Distance travelled is equivalent to the area under the graph. 38 to 40 squares counted. Each square is equivalent to 0.05 m. So distance is (eg) 38 × 0.05 = 1.9 (or 2.0) m.
3. a. 6.0 ms^{-1} b. Answer between 21 and 24 m (count the number of squares under the line). c. Use your answer from part b: $$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$ For example, $$\frac{21}{15} = 2.8\ ms^{-1}$$ Or $$\frac{24}{7.5} = 3.2\ ms^{-1}$$

4.

a. Using the formula

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

Values for:

Initial velocity u = (0.20 (m s^{-1}) or 20 (cm s^{-1}) 200 (mm s^{-1}))

Final velocity v = (0.25 (m s^{-1}) or 25 (cm s^{-1}) or 250 (mm s^{-1}))

So

$$a = \frac{0.25 - 0.20}{1.19}$$

$$= 4.2 \times 10^{-2} \text{ (m s}^{-2}\text{)}$$

b. A continuous, ruled straight best fit line through first and last points for this set of data.

Gradient calculated from change in y / change in x

A = 0.045 range (0.042 to 0.053)

c. Height will be calculated using

$$\frac{\text{your gradient A}}{4.9}$$

For example, using the value from part b the height would be

$$\frac{0.045}{4.9} = 9.2 \times 10^{-3} \text{ m}$$

5.

a. Missing values are 5.1 and 7.1
The second column is the first column squared.

b. Both plotted points to nearest mm.
Best line of fit to points.

The line should be a straight line with approximately an equal number of points on either side of the line.

c. Use a large triangle and annotate this on the graph.
Gradient value in the range 0.190 to 0.210 (this depends on your line of best fit).

d.

$$R = \frac{1}{\text{gradient}} = 5\ \Omega$$

Because the power is plotted on the y axis

power = potential difference ^{2} / resistance

using y = mx + c

gives m as 1/resistance

6.

a. Rearranging the formula $c = f \lambda$

The speed of light (c) is taken from the Formula sheet: 3.00×10^8

So the two missing frequencies are 5.31×10^{14} and 6.38×10^{14} Hz.

b. Both points correctly plotted.

Well drawn straight line of best fit.

The orange LED point (4.80, 1.54) is anomalous. The line should follow the trend of the points (ignoring the anomalous point) with an even scatter of points on either side of the line.

c. Use a large triangle and annotate this on the graph.

Gradient in range 0.44 to 0.46 (0.435 to 0.464) $\times 10^{-14}$

(This depends on your line of best fit.)

d. Recognition that the gradient = h/e

h = gradient $\times 1.60 \times 10^{-19}$

For example

$h = 0.45 \times 10^{-14} \times 1.60 \times 10^{-19}$

$h = (6.95 \text{ to } 7.44) \times 10^{-34}$ Js

e. Calculated using

$$\frac{\text{Difference between the expected value and the one you obtained}}{\text{actual value}} \times 100$$

For example, if gradient in d calculated as 7.2×10^{-34}

The percentage difference would be

$$\frac{(7.2 \times 10^{-34} - 6.63 \times 10^{-34})}{6.63 \times 10^{-34}} \times 100$$

$$= 8.6\%$$

(Range could be from 4.8% to 12.2%)